**U.S. DEPARTMENT OF COMMERCE**
**National Technical Information Service**

PB-283 217

# A Course on Troubleshooting O and M Problems in Wastewater Treatment Facilities - Student Notebook

American Public Works Association, Chicago, Ill

Prepared for

National Training and Operational Technology Center, Cincinnati, Ohio

Aug 76

## TECHNICAL REPORT DATA
*(Please read Instructions on the reverse before completing)*

1. REPORT NO.
EPA-430/1-77-002

2.

3. RECIPIENT'S ACCESSION NO.
PB283217

4. TITLE AND SUBTITLE
Troubleshooting O&M Problems in Wastewater Treatment Facilities - Student Manual

5. REPORT DATE
August 1976 (date of issue)

6. PERFORMING ORGANIZATION CODE

7. AUTHOR(S)
American Public Works Association
Chicago, Illinois

8. PERFORMING ORGANIZATION REPORT NO.

9. PERFORMING ORGANIZATION NAME AND ADDRESS
National Training & Operational Technology Center
Municipal Operations & Training Division, WPO
Environmental Protection Agency
Cincinnati, Ohio 45268

10. PROGRAM ELEMENT NO.

11. CONTRACT/GRANT NO.
T900535-01-0

12. SPONSORING AGENCY NAME AND ADDRESS
same

13. TYPE OF REPORT AND PERIOD COVERED
Final

14. SPONSORING AGENCY CODE
700/02

15. SUPPLEMENTARY NOTES
The Student Manual is to be used only with Instructors Manual

16. ABSTRACT

The Student Manual contains summaries, flow charts, check lists, diagrams and references needed to participate in the course, "Troubleshooting O&M Problems in Wastewater Treatment Plants." As the course proceeds the instructor adds to the notebook with handouts and problems for the trainee. It can only be used in conjunction with the Instructors Manual.

17. KEY WORDS AND DOCUMENT ANALYSIS

| a. DESCRIPTORS | b. IDENTIFIERS/OPEN ENDED TERMS | c. COSATI Field/Group |
|---|---|---|
| wastewater, wastewater treatment, oxidation lagoons, activated sludge, solid handling, performance evaluations, inspections | troubleshooting, problem-solving, operations, maintenance, process control | 5I, 13B |

| | | |
|---|---|---|
| 18. DISTRIBUTION STATEMENT | 19. SECURITY CLASS *(This Report)*<br>Unclassified | 21. NO. OF PAGES<br>211 |
| | 20. SECURITY CLASS *(This page)*<br>Unclassified | 22. PRICE<br>A10-A01 |

EPA Form 2220-1 (9-73)

PB 283 217

EPA-430/1-77-002

# TROUBLESHOOTING O & M PROBLEMS IN WASTEWATER TREATMENT FACILITIES

## STUDENT NOTEBOOK

U.S. ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF WATER PROGRAM OPERATIONS

REPRODUCED BY
NATIONAL TECHNICAL
INFORMATION SERVICE
U. S. DEPARTMENT OF COMMERCE
SPRINGFIELD, VA. 22161

EPA-430/1-77-002

## A COURSE ON

# TROUBLESHOOTING
# O & M PROBLEMS
# IN
# WASTEWATER TREATMENT FACILITIES

## STUDENT NOTEBOOK

August 1976

This course was developed by the American Public Works Association in cooperation with the Municipal Operations Branch of the U.S. Environmental Protection Agency under Grant No. T 900535-01-0

## ACKNOWLEDGEMENTS

This course was developed under EPA Training Grant No. T900535-01-0, awarded to the American Public Works Association Research Foundation, Chicago, Illinois, on March 1, 1975. The following persons contributed significantly to the course development and content:

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# TROUBLESHOOTING OPERATING AND MAINTENANCE PROBLEMS AT WASTEWATER TREATMENT FACILITIES

## COURSE OBJECTIVES:

- To train state and federal water pollution control personnel in the *process of troubleshooting* and problem solving for operational problems at municipal wastewater treatment plants. (And other persons in the water pollution control profession for whom the process of troubleshooting would be useful.)
- To upgrade the level of *technical assistance* provided to wastewater treatment plant operators by state and federal water pollution control agencies and personnel.
- To create an awareness for the need for *cooperative relationships and attitudes* between local, state, and federal agency staffs responsible for treatment plant performance and operations.
- To expose state and federal pollution control personnel to realistic *treatment plant operating problems*, their causes, effects, and methods of correction.
- To provide an overview of wastewater treatment plant operations and processes to serve as a *technical review* and supplement for water pollution control agency staffs.

## AT THE COMPLETION OF THIS COURSE, STUDENTS WILL BE ABLE TO:

a. Assist treatment plant operators in a troubleshooting capacity by utilizing a constructive approach and positive attitude.

b. Identify operational problems in wastewater treatment plants, and their likely causes.

c. Utilize the process of troubleshooting to evaluate plant performance, and to conduct the necessary observations, tests, and process controls in the analysis of plant operating problems.

d. Identify and recommend alternative corrective actions to plant operating problems.

e. Recommend measures for the long range implementation of plant improvements and to monitor, document, and follow-up on the results of actions taken.

## SUMMARY OF

## Survey of Federally Funded Treatment Facilities
## (Done under Section 210 of the Water Pollution Control Act)

### 1. PLANT PERFORMANCE

a. Less than half of secondary facilities are meeting secondary efflent requirements.

b. Trickling filters have more difficulty meeting requirements than activated sludge.

c. 4,400 secondary plants may not be in compliance.

### 2. MARGINAL PLANTS

a. 20% of all secondary plants — up to 1,700 nationally, are classified as "marginal performers"

b. Marginal performers — do not meet secondary requirements, but

c. They can meet secondary requirements without significant investments in new construction, thus

d. Some 1,700 plants could achieve requirements through O&M and minor plant modifications.

### 3. LABORATORY FACILITIES

a. Many plants had inadequate lab facilities, thus

b. Many facilities could not provide adequate operational data

c. Testing for process control is low due to inadequate lab facilities

d. Illinois Survey — With an adequate lab, plant performance can be increased by 20%.

### 4. OTHER FACTORS

a. Plants with good maintenance management programs perform better

b. Attention to routine training, short courses, etc., has been lacking

### 5. SURVEY CONCLUSIONS

a. Improved O&M practices, laboratory facilities, and training can lead to *major* levels of plant performance improvements, and will enable 20% of all secondary plants to meet existing requirements

b. Based on EPA experience, direct operational assistance to plant operators by providing an effective control strategy can result in significant improvements in effluent quality

c. Assistance programs exemplified by work of A. W. West, National Waste Treatment Center, EPA Cincinnati — considerable success in providing control methodologies for activated sludge facilities

### 6. SIGNIFICANCE

a. As a result of EPA Survey and conclusions, troubleshooting O&M problems, and O&M technical assistance must be stressed as an important part of the overall cleanup effort for water pollution

*For more information see Gilbert, W.G. (listing in References)*

## SCENARIO OF BOARD GAME

The Board of Trustees of Independence County, located in the urban-industrial center of your state, has recently voted to establish a consolidated, county-wide sanitary district which will construct, own, and operate all municipal sewerage facilities in the county. The District will assume jurisdiction over all existing treatment plants in the county, including those in the less populated, rural areas, and those serving private subdivisions. In all, when it comes into existence, the District will acquire the following facilities:

a. Three (3) activated sludge, (secondary treatment) plants, with industrial waste loads. Capacity - 2.5 to 60 mgd.
b. Five (5) trickling filtration, (secondary treatment) plants, some with industrial waste loads, capacity - .75 to 9.0 mgd.
c. Twelve (12) aerated lagoons, capacity - .10 to .70 mgd.
d. One (1) primary treatment plant, 5 mgd.
e. Two (2) spray irrigation facilities, handling a total load of .25 mgd following secondary treatment.
f. One (1) advanced waste treatment plant, .2 mgd, which consists of chemical clarification, sand filtration, activated carbon adsorption, with nitrification.
g. A variety of sludge handling facilities, including anaerobic digestion, sludge drying beds, vacuum filtration, incineration and landfill.
h. Twenty-five (25) "package" treatment plants serving residential subdivisions.

Your boss, the Commissioner of Water Pollution Control for the State, has promised the new Executive Director of the Sanitary District, the State's full cooperation in assisting the District assume the operation of all of its facilities. The Executive Director, brought in from another State for the job, has heard rumors of faulty and inefficient operations at many of the facilities he is about to control, and has seen some evidence to this effect in the operating records of the District's plants. Because of his concerns, the Commissioner has promised to send a team of the State's top field people to troubleshoot at the plants in Independence County.

You are a specialist in treatment operations for the State, but have been working in the State Capitol and you are unfamiliar with the plants, the problems and the personnel in the new Independence County Sanitary District. You will head a team of three (3) other specialists and will be assigned to assist the District in improving treatment plant operations throughout the county. You will rely on the judgment of the members of your team, and of course, on the plant operators, but you have been given the final authority to determine what, if any, changes need to be made at the plants which you are about to evaluate. All plant superintendents and operators in the District have been notified that your evaluation team will visit their plants to assist them in upgrading performance. Your recommendations are to go directly to the new Executive Director.

## REFERENCES – COURSE OVERVIEW

Gilbert, W.G., "Municipal Wastewater Treatment: The Relation of Operation and Maintenance Activities to Plant Efficiency," Presented at 48th Annual Conference, Water Pollution Control Federation, Miami Beach, October, 1975.

Azan, K.M., and Boyko, B.I., "Identification of Problem Areas in Water Pollution Control Plants," Research Report No. 15, Ontario Ministry of the Environment, 1973.

Public Law 92-500, Federal Water Pollution Control Act Amendments, Adopted October 18, 1972.

# NOTES ON TROUBLESHOOTER BEHAVIOR

**Definition of Troubleshooting:**

Troubleshooting is the practice of problem solving — as applied to an existing facility in use and experiencing operational problems which effect its performance.

**Troubleshooting is a Process Which:**

1. May require repeated visits over a period of time.
2. Often cannot produce a single "right" answer.
3. Provides an *approach* to solving problems.
4. Requires an indirect role; a troubleshooter's job is to *assist* the operator.
5. Depends on human *and* technical skills.

**Troubleshooting goals include:**

1. Repairing breakdown or immediate problem.
2. Preventing reoccurrence of problem.
3. Improving long-run O&M.
4. Upgrading overall plant efficiency.

**Troubleshooters are:**

1. Investigators
2. Problem solvers
3. Mechanics
4. Psychologists
5. Assistants

**Characteristics of Good Troubleshooter Behavior:**

1. Thorough and open communication
2. Ability to listen and understand
3. Honesty and sincerity
4. Respect for the operator
5. Understanding his limitations — knowing when to get help
6. Assists the operator — works through mutual participation
7. Judgment and common sense
8. Interest in the operator's problems

# INSPECTION CHECKLISTS*

## RE-INSPECTION PREPARATION CHECKLIST

- Review past inspection reports
- Review as-built plant drawings
- Review plant flow diagrams
- Review plant performance records
- Review plant design parameters

## ROUTINE INSPECTION CHECKLIST

The following items should be considered during a routine inspection:

- Plant site maintenance, including landscaping, fencing, and buffer zone
- Plant aesthetics, including odors, building maintenance, and painting requirements of outside visible structures
- Plant operation and maintenance records
- Plant staffing for operation and maintenance
- Plant laboratory, including equipment, test procedures, and staff
- Plant influent
- Plant effluent
- Equipment records
- Safety equipment
- Sampling locations, methods, and frequency
- Solids disposal, both grit and digested sludge
- Plant bypass frequency
- Infiltration inflow

* This check list is reproduced from Appendix B, "Basic Elements of State/Federal Programs on Operation & Maintenance of Municipal Wastewater Treatment Facilities," CH2M HILL, report to U.S. EPA, 3 February, 1975

# DETAILED INSPECTION CHECKLIST

The detailed inspection checklist outlined is based on unit operations. For each individual plant, consideration should be given only to those unit operations relevant to that specific plant.

## GENERAL

Consider all items outlined on the "Routine Inspection Checklist."

## SCREENING AND COMMINUTION

- Clean area
- Odors
- Storage of screenings
- Frequency of removal
- Maintenance of mechanical equipment

## GRIT REMOVAL

- Amount of grit removed
- Amount of grit in other plant units
- Volatile solids in grit
- Maintenance of mechanical equipment
- Clean area
- Odors
- Adequate venting of grit chamber for enclosed areas; explosive or toxic gases
- Explosion-proof lights and other items in enclosed areas

## SEDIMENTATION BASINS

- Clean area
- Safety railings
- Maintenance of mechanical equipment
- Odor problems
- Corrosion on metal and concrete
- Floating sludge or gas bubbles

- Frequency of scum removal and if scum is allowed to accumulate on scum barrier
- Raw sludge pump maintenance and cycling frequency
- Pressure gauges (are they provided on sludge pumps?) – this gives operation conditions and tells of stoppages in sludge lines
- Plugging in sludge lines and valves
- Raw sludge removal and percent solids content
- Percentage removal of SS and BOD

## BIOLOGICAL TREATMENT UNITS

### Trickling Filters

- Dosing performance
- Filter flies and odors
- Corrosion of piping
- Maintenance of equipment
- Clogging of nozzles
- Condition of filter media, that is, ponding
- Cleaning program of underdrains
- Performance of final clarifiers (similar to primary sedimentation outline)
- Frequency of sludge handling from high rate system, as it becomes septic faster than from standard system
- Recirculation volumes
- Condition of biological growth on filter media
- DO of effluent
- Icing of filter surface if inspection is performed in cold climatic regions

**Activated Sludge Process**

- Frothing in aeration tank
- Corrosion
- Maintenance of equipment such as blowers, filters, diffusers, air lines, sludge pumps, and scrappers
- MLSS in aeration tank
- Flow and concentration of return sludge
- DO in aeration tank
- Bulking sludge in final clarifiers
- Rising sludge in final clarifier
- Waste sludge flow
- Sludge depths in hoppers and cycling rates of the sludge pumps
- Condition of launders on final clarifier
- Sludge valves and lines for sign of plugging
- Final clarifiers for skimmings removal
- Safety measures, such as guard rails

## CHLORINATION

- Chlorine requirements based on effluent chlorine residual requirements and coliform organisms
- Equipment maintenance and pipe corrosion
- Safety measures such as gas masks (cannister and self-contained breathing), separate ventilation of chlorine feed rooms, explosion-proof electrical fixtures to prevent corrosion, storage of chlorine cylinders, and capped valves on chlorine cylinders
- Check method and frequency of cleaning chlorine contact table

## SLUDGF DIGESTION

- Raw sludge solids concentration
- Percent volatile matter in raw sludge
- Temperature ranges of operation
- Sludge pumps for operation and maintenance
- pH control
- Mixing and/or recirculation
- Safety measures
- Gas production
- Percent reduction of volatile matter for digesting process
- Quality of supernatant for volatile acids, alkalinity, BOD, SS
- Supernatant withdrawn and recycled back into plant headworks

## SLUDGE CONDITIONING

- Process used, such as gravity, elutriation, pressure flotation, or chemical coagulation
- Proper lab tests conducted, depending on the process
- Equipment operation and maintenance
- Solids uniformity and grit
- Process efficiency
- Odors, oils, and greases
- Clean area

## SLUDGE DEWATERING

- Process such as drying beds, vacuum filters, or centrifuges
- Equipment operation and maintenance
- Clean area
- Odors, oils, and greases
- Check that adequate laboratory tests are conducted depending on dewatering process used

## SLUDGE DISPOSAL

- Process such as incineration, sanitary landfilling, or soil conditioner
- Equipment operation and maintenance
- Odor and storage area
- Clean area

## EQUIPMENT (GENERAL)

- Operation and maintenance records of all major equipment
- Manufacturer's parts and operation and maintenance manuals of all major equipment
- Operation and maintenance of equipment according to manufacturer's recommendation
- Excessive downtime
- Preventive maintenance program
- Calibration of instruments
- Operation and maintenance of instruments

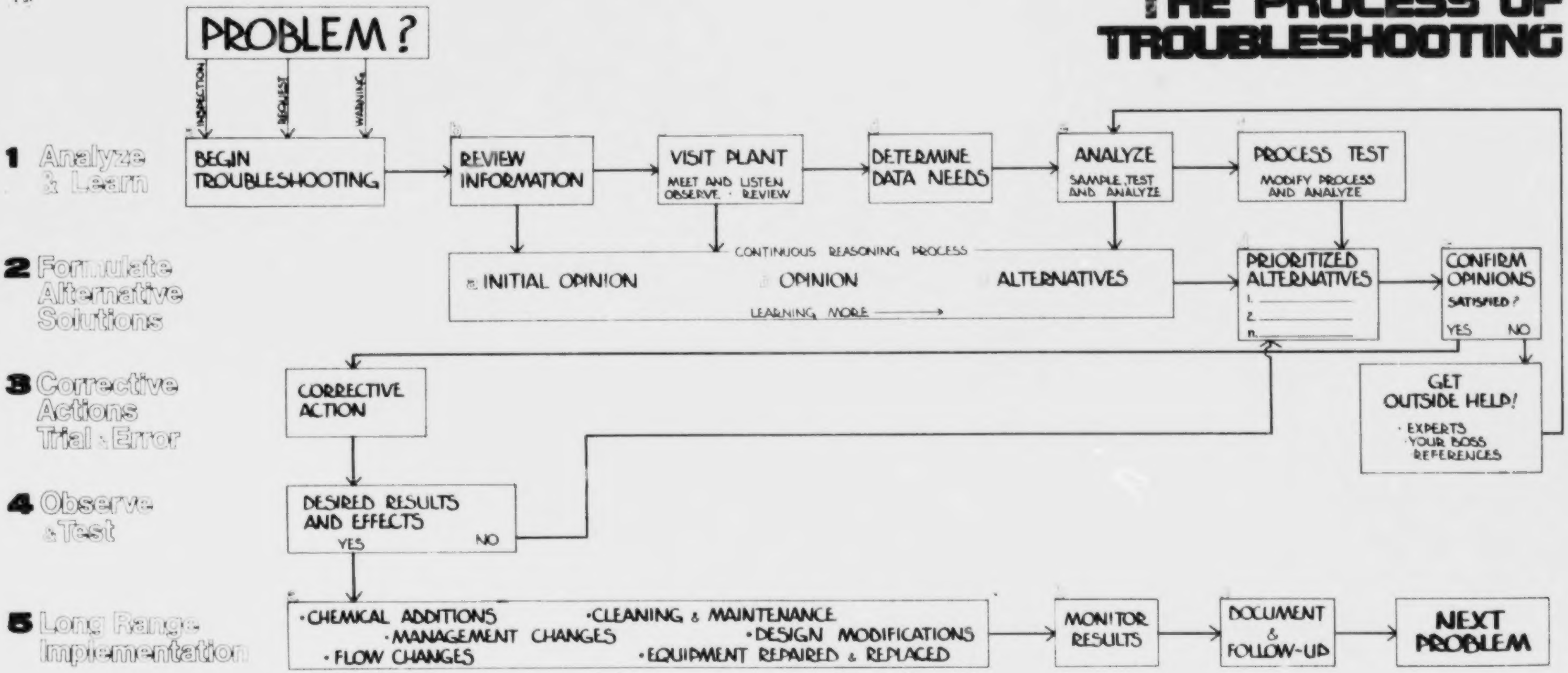
## RECORDS (GENERAL)

- Availability at plant of as-built design drawings
- Availability of operational records
- Availability of laboratory records
- Data management procedures

## STAFFING (GENERAL)

- Adequate staff available at facility for both the plant and laboratory
- Certification of plant operators
- Training programs for staff operators
- Shift requirements for operators
- Adequate administrative staff and supervision
- Adequate salaries for staff

# THE PROCESS OF TROUBLESHOOTING


PROBLEM?
INSPECTION
REQUEST
WARNING
1 Analyze & Learn
BEGIN TROUBLESHOOTING
REVIEW INFORMATION
VISIT PLANT
MEET AND LISTEN
OBSERVE · REVIEW
DETERMINE DATA NEEDS
ANALYZE
SAMPLE, TEST AND ANALYZE
PROCESS TEST
MODIFY PROCESS AND ANALYZE
2 Formulate Alternative Solutions
CONTINUOUS REASONING PROCESS
INITIAL OPINION
OPINION
ALTERNATIVES
LEARNING MORE
PRIORITIZED ALTERNATIVES
1.
2.
n.
CONFIRM OPINIONS
SATISFIED?
YES
NO
GET OUTSIDE HELP!
· EXPERTS
· YOUR BOSS
REFERENCES
3 Corrective Actions Trial & Error
CORRECTIVE ACTION
4 Observe & Test
DESIRED RESULTS AND EFFECTS
YES
NO
5 Long Range Implementation
· CHEMICAL ADDITIONS
· MANAGEMENT CHANGES
· FLOW CHANGES
· CLEANING & MAINTENANCE
· DESIGN MODIFICATIONS
· EQUIPMENT REPAIRED & REPLACED
MONITOR RESULTS
DOCUMENT & FOLLOW-UP
NEXT PROBLEM

## SOURCES OF INFORMATION FOR TROUBLESHOOTERS

1. In-plant information
    a. Plant log and records
    b. NPDES
    c. Plant O&M manual

2. EPA Materials
    a. Inspection and evaluation forms
    b. Performance evaluation manual
    c. Case histories – plant performance
    d. Technology transfer and other technical information

3. Other technical materials
    a. State manuals and guidelines
    b. WPCF

4. Other persons who can be called for assistance
    a. The operator
    b. Other local people
    c. State specialists
    d. Federal specialists
    e. Operations consultants

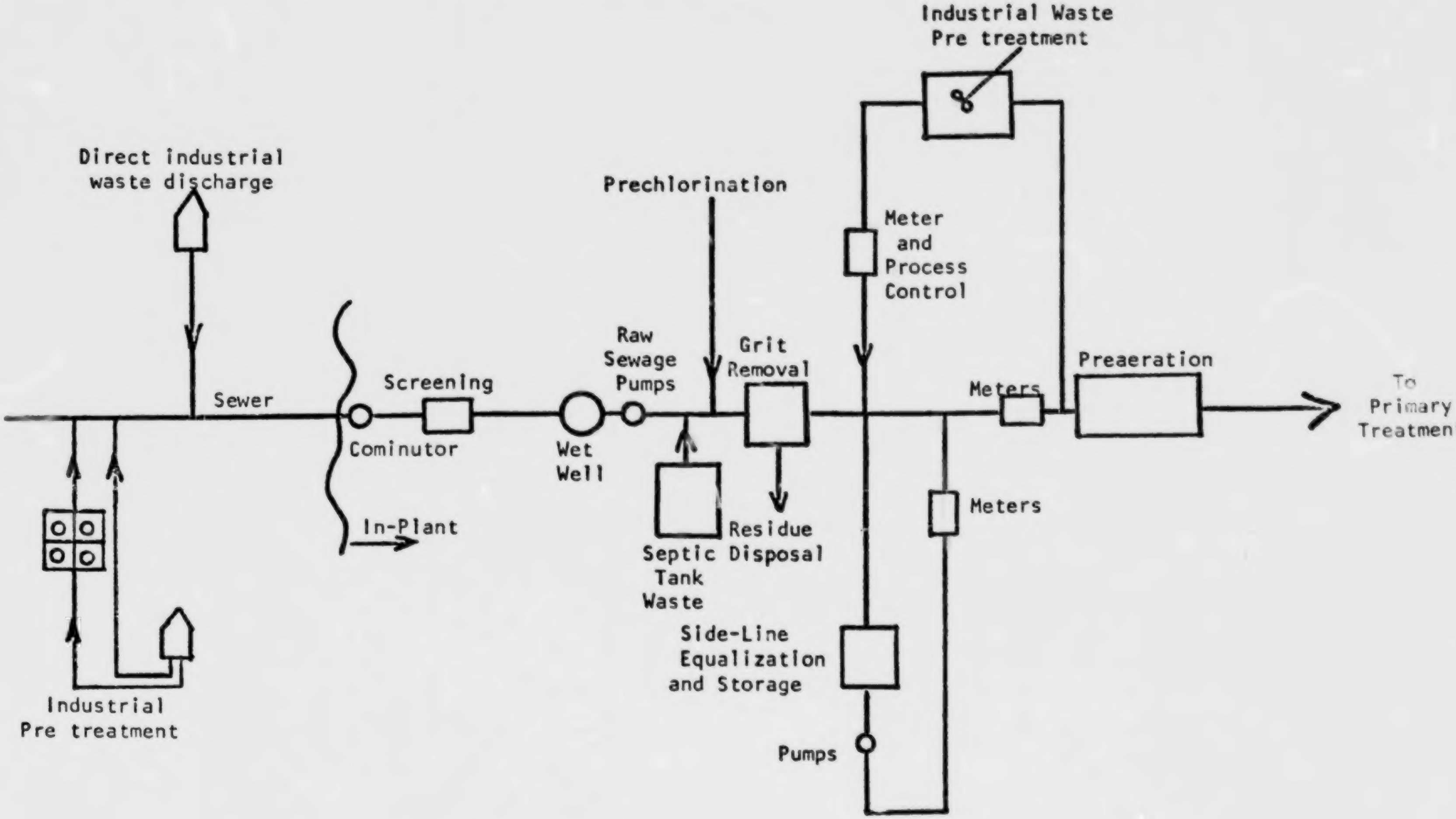
5. Personal observations
    a. Plant personnel and operators
    b. Physical conditions of plant
    c. Working conditions
    d. Inter-personal relationships
    e. Management behavior

6. Analyses and tests
    a. Compare plant performance to normal operating characteristics
    b. Sampling and testing program
    c. Process modifications and testing

## LESSON: PREPRIMARY TREATMENT

### Index of Notebook Materials

| Pages | Material | Use in Lesson |
|---|---|---|
| PR 1 | Schematic Flow diagram of pretreatment process components | Used by instructor Subdivision 1, Section 1 |
| PR 2<br>PR 3 | Plant information & background<br>Problem Worksheet | For use by student groups in solving problem assigned in Subdivision 1 |
| PR 4 - 16 | Sample Sewer Use Ordinance | For student reference in relation to Subdivision 1, Section III, on Sewer Use Ordinances |
| PR 17 - 18 | Flow Diagrams on Flow Equalization taken from "Upgrading Existing Wastewater Treatment Plants" EPA | For student reference in Subdivision 1, Section IV, Flow Equalization. |
| PR 19 | Table on Raw Sludge Characteristics and Relationship to other Processes | Used by instructor Subdivision 3, Section I |
| PR 20 - 22 | Troubleshooting Guide, Primary Treatment | For Student Reference Subdivision 3, Section III, on Troubleshooting |
| PR 23 | References | |


Direct industrial waste discharge
Sewer
Industrial Pre treatment
Screening
Cominutor
In-Plant
Wet Well
Raw Sewage Pumps
Prechlorination
Septic Tank Waste
Grit Removal
Residue Disposal
Meter and Process Control
Industrial Waste Pre treatment
Side-Line Equalization and Storage
Pumps
Meters
Meters
Preaeration
To Primary Treatment

Schematic Flow Diagram of Pretreatment Process Components

**Plant Information and Background**

**GROUP** ______________________

## TROUBLESHOOTING PROBLEM – PRETREATMENT

### PLANT BACKGROUND:

Plant flow is excess of 10.0 MGD

Essential Equipment:

1. Pump station following a 2 inch bar screen
2. Comminutor in alternate channels
3. Pumps and preliminaries in a below grade pit
4. Primary treatment (2) clarifiers
5. Activated sludge surface aerators
6. Final clarifiers (2)
7. Anaerobic digesters

### INITIAL OBSERVATION AND ANALYSIS BY TROUBLESHOOTER:

The plant facility has what appears to be adequate capacity but little versatility. Preliminary screen has an open channel behind it with poor facilities for cleaning screens and lifting screening out of the pit (approximately 25 ft down). Flow distribution, measurement, and control devices require real ingenuity and agility to master the situation and to achieve effective plant performance.

### OBSERVATIONS ON MANAGEMENT BEHAVIOR:

1. Laboratory facilities and support appear weak
2. The plant is understaffed
3. Comments from staff lead you to believe that they get little support from city hall for their problems
4. Staff appear to be hard working, and trying
5. Records are scant except for the absolute minimum. There is little confidence in the records, except that they accurately show the plant to be not performing up to its design
6. Process controls are limited. The staff is too busy just keeping the wastewater moving and solving problems like the one shown in the slide

**GROUP** ______________________________ **Problem Worksheet**

## TROUBLESHOOTING PROBLEM — PRETREATMENT

Student groups should answer the following questions.

1. What is the location of the problem shown in the slide?

2. What is the nature of the problem?

3. What is the most likely cause of the problem, based upon your knowledge of the plant as a troubleshooter?

4. What corrective actions would you recommend?

5. Do you see additional problems shown in the slide?

You have 10 minutes to complete this worksheet, at which time the problem will be discussed by the class.

# SAMPLE
# SEWER USE ORDINANCE

## ARTICLE I
## DEFINITIONS

Unless the context specifically indicates otherwise, the meaning of terms used in this ordinance shall be as follows:

Sec. 1. "Biochemical oxygen demand" (BOD) shall mean the quantity of oxygen utilized in the biochemical oxidation of organic matter under standard laboratory procedure in five (5) days at 20°C, expressed in milligrams per liter.

Sec. 2. "Building drain" shall mean that part of the lowest horizontal piping of a drainage system which receives the discharge from soil, waste, and other drainage pipes inside the walls of the building and conveys it to the building sewer, beginning five (5) feet (1.5 meters) outside the inner face of the inner face of the building wall.

Sec. 3. "Building sewer" shall mean the extension from the building drain to the public sewer or other place of disposal, also called house connection.

Sec. 4. "Chemical oxygen demand" (COD) shall mean the quantity of oxygen utilized in the chemical oxidation of organic matter under standard laboratory procedures expressed in milligrams per liter.

Sec. 5. "Combined sewer" shall mean a sewer intended to receive both wastewater and storm or surface water.

Sec. 6. "Compatible pollutant" shall mean BOD, suspended solids, acceptable pH range, and fecal coliform bacteria, plus additional pollutants identified in the NPDES permit if the publicly owned treatment works was designed to treat such pollutants, and in fact does remove such pollutants to a substantial degree. Examples of such additional pollutants may include: a) COD; b) total organic carbon; c) phosphorus and phosphorus compounds; d) nitrogen and nitrogen compounds; e) fats, oils, and greases of animal or vegetable origin except as prohibited under Article ( ), Sec 4.

Sec. 7. "Engineer" shall mean the Engineer of the [Village] of ( ) or his authorized representative.

Sec. 8. "Federal Act" shall mean the Federal Water Pollution Control Act Amendments of 1972, Public Law 92-500, and any amendments thereto; as well as any guidelines, limitations, and standards promulgated by the U.S. Environmental Protection Agency pursuant to the Act.

Sec. 9. "Floatable oil" is oil, fat, or grease in a physical state such that it will separate by gravity from wastewater by treatment in an approved pretreatment facility.

Sec. 10. "Garbage" shall mean the animal and vegetable waste resulting from the handling, preparation, cooking, and serving of food.

Sec. 11. "Incompatible pollutant" shall mean any pollutant which is not a compatible pollutant as defined in Sec. 6.

Sec. 12. "Industrial wastes" shall mean the wastewater from industrial processes, trade, or business as distinct from domestic or sanitary wastes.

Sec. 13. "Major contributing industry" shall mean an industrial user of the publicly-owned treatment works that: (a) has a flow of 50,000 gallons or more per average work day; (b) has a flow greater than five (5) percent of the flow carried by the municipal system receiving the waste; (c) has in its waste, a toxic pollutant in toxic amounts as defined in standards issued under Section 307(a) of the Federal Act; or (d) is found by the permit issuance authority in connection with the issuance of an NPDES permit to the publicly owned treatment works receiving the waste, to have significant impact, either singly or in combination with other contributing industries, on that treatment works or upon the quality of effluent from that treatment works.

Sec. 14. "May" is permissive; "Shall" is mandatory.

Sec. 15. "Natural outlet" shall mean any outlet, including storm sewers and combined sewer overflows, into a watercourse, pond, ditch, lake, or other body of surface or groundwater.

Sec. 16. "NPDES" permit shall mean the National Pollutant Discharge Elimination System permit.

Sec. 17. "Person" shall mean any individual, firm, company, association, society, corporation, or group.

Sec. 18. "pH" shall mean the reciprocal of the logarithm of the hydrogen ion concentration. The concentration is the weight of hydrogen ions, in grams, per liter of solution. Pure water, for example, has a pH value of 7 and a hydrogen ion concentration of $10^{-7}$

Sec. 19. "Pollutant" shall mean dredged spoil, solid waste, incinerator residue, wastewater, garbage, wastewater sludge, munition, wrecked or discarded equipment, rock, sand, cellar dirt, and industrial, municipal, and agricultural waste discharged into water.

Sec. 20. "Properly shredded garbage" shall mean the wastes from the preparation, cooking, and dispensing of food that have been shredded to such a degree that all particles will be carried freely under the flow conditions normally prevailing in public sewers, with no particle greater than 1/2 inch (1.27 centimeters) in any dimension.

Sec. 21. "Pretreatment" shall mean the treatment of wastewaters from sources before introduction into publicly owned wastewater treatment facilities.

Sec. 22. "Public sewer" shall mean a common sewer controlled by a governmental agency or public utility.

Sec. 23. "Sanitary sewer" shall mean a sewer that carries liquid and water-carried wastes from residences, commercial buildings, industrial plants, and institutions together with minor quantities of ground, storm, and surface waters that are not admitted intentionally.

Sec. 24. "Slug" shall mean any discharge of water or wastewater which in concentration of any given constituent or in quantity of flow exceeds for any period of duration longer than fifteen (15) minutes more than five (5) times the average twenty-four (24) hour concentration of flows during normal operation and shall adversely affect the collection system and/or performance of the wastewater treatment works.

Sec. 25. "Storm drain" (sometimes termed "storm sewer") shall mean a drain or sewer for conveying water, groundwater, subsurface water, or inpolluted water from any source.

Sec. 26. "Superintendent" shall mean the [Superintendent of wastewater facilities, and/or of wastewater treatment works, and/or of water pollution control] of the [Village] of [ ], or his authorized deputy, agent, or representative.

Sec. 27. "Suspended solids" shall mean total particulate matter that either floats on the surface of, or is in suspension in, water, wastewater, or other liquids, and that is removable by laboratory filtering as prescribed in "Standard Methods for the Examination of Water and Wastewater" and referred to as nonfilterable residue.

Sec. 28. "Toxic pollutants" shall include but not necessarily be limited to aldrin-dieldrin, benzidine, cadmium, cyanide, DDT-endrin, mercury, polychlorinated biphenyls (PCB's) and toxaphene. Pollutants included as "toxic" shall be those promulgated as such by the United States Environmental Protection Agency.

Sec. 29. "Unpolluted water" is water of quality equal to or better than the effluent criteria in effect or water that would not cause violation of receiving water quality standards and would not be benefited by discharge to the sanitary sewers and wastewater treatment facilities provided.

Sec. 30. "Wastewater" shall mean the spent water of a community. From the standpoint of source, it may be a combination of the liquid and water-carried wastes from residences, commercial buildings, industrial plants, and institutions, together with any groundwater, surface water, and stormwater that may be present.

Sec. 31. "Wastewater facilities" shall mean the structures, equipment, and processes required to collect, carry away, and treat domestic and industrial wastes and dispose of the effluent.

Sec. 32. "Wastewater treatment works" shall mean an arrangement of devices and structures for treating wastewater, industrial wastes, and sludge. Sometimes used as synonymous with "waste treatment plant" or "wastewater treatment plant" or "water pollution control plant."

Included among the definitions of a particular ordinance should be those for such terms as "city," "village" and various officials as are locally applicable.

## ARTICLE (     )

## Use of Public Sewers

Sec. 1. *Prohibition on Unpolluted Water* – No person shall discharge or cause to be discharged any (unpolluted) stormwater, surface water, groundwater, roof runoff, subsurface drainage, uncontaminated cooling water, or unpolluted industrial process waters to any sanitary sewer. Any existing roof drain connections to sanitary (or combined) sewers shall be connected into an available storm sewer or shall be disconnected above ground in the manner approved by the [Board of Public Affairs]. The owner of all buildings situated within the [Village] is required at his expense to disconnect all existing roof drains from sanitary [and combined] sewers in accordance with the provisions of this chapter within 90 days after the date of official notice to do so.

Sec. 2. *Allowable Discharge of Unpolluted Water* – Stormwater and all other unpolluted drainage shall be discharged to such sewers as are specifically designated as combined sewers or storm drains or to a natural outlet approved by the [Board of Public Affairs] and other regulatory agencies. Unpolluted industrial cooling water or process waters may be discharged on approval by the [Board of Public Affairs] to a storm sewer, or natural outlet.

Sec. 3. *Substances Prohibited* – No person(s) shall discharge or cause to be discharged any of the following described waters or wastes to any public sewers [or treatment works]:

a) Any gasoline, benzene, naptha, fuel oil, or other flammable or explosive liquid, solid, or gas

b) Any waters or wastes having a pH lower than [6.0] or having any other corrosive property capable of causing damage or hazard to structures, equipment, and personnel of the wastewater works.

c) Solid or viscous substances in quantities or of such size capable of causing obstruction to the flow in sewers or other interferences with the proper operation of the wastewater facilities such as, but not limited to, ashes, bones, cinders, sand, mud, straw, shavings, metal, glass, rags, feathers, tar, plastics, wood, unground garbage, whole blood, paunch manure, hair and fleshings, entrails, and paper dishes, cups, milk containers, etc., either whole or ground by garbage grinders.

Sec. 4. *Substances Limited* – The following described substances, materials, waters, or waste shall be limited in discharges to municipal systems to concentrations or quantities which will not harm either the sewers, wastewater treatment process or equipment, will not have an adverse effect on the receiving stream, or will not otherwise endanger lives, limbs, public property, or constitute a nuisance. The [Superintendent] may set limitations lower than the limitations established in the regulations below if in his opinion such more severe limitations are necessary to meet the above objectives. Deliberate dilution with unpolluted water to meet the concentrations established in the regulations below shall not be acceptable. In forming his opinion as to the acceptability, the [Superintendent] will give consideration to such facts as the quantity of subject waste in relation to flows and velocities in the sewers, materials of construction of the sewers, the wastewater treatment process employed, capacity of the wastewater treatment plant, degree of treatability of the waste in the wastewater treatment plant, and other pertinent factors. The limitations or restrictions on materials or characteristics of waste or wastewater discharged to the sanitary sewer which shall not be violated without approval of the [Superintendent] are as follows:

a) Wastewater having a temperature higher than 150°F

b) Wastewater containing more than 50 milligrams per liter of petroleum oil, nonbiodegradable cutting oils, product of mineral oil origin, or floatable oils, fat, wax, or grease.

c) Any garbage that has not been properly shredded. Garbage grinders may be connected to sanitary sewers from homes, hotels, institutions, restaurants, hospitals, catering establishments or similar places where garbage originates from the preparation of food in kitchens for the purpose of consumption on the premises or when served by caterers.

d) Any waters or wastes containing solids, liquids, or gases in sufficient quantity, either singly or by interaction with other wastes to injure or interfere with any wastewater treatment process, constitute a hazard to humans or animals, create a public nuisance, or create any hazard in the receiving waters of the Wastewater Treatment Plant, including, but not limited to cyanides, hexavalent chromium, copper, zinc, cadmium, nickel and phenols in the wastes as discharged to the public sewer. The following concentrations shall not be exceeded in industrial wastes discharged to the public sewers:

total cyanide (CN), 0.5 milligrams per liter (mg/l)

hexavalent chromium, 1.0 mg/l

copper, 1.0 mg/l

zinc, 1.0 mg/l

cadmium, 0.2 mg/l

nickel, 2.0 mg/l

phenols, 0.2 mg/l

lead, 0.5 mg/l

mercury, 0.01 mg/l

silver, 0.2 mg/l

These maximum concentrations may be changed as necessary by the [Superintendent] or state regulatory agencies based on new information concerning inhibitory substances or to protect treatment plant processes. Industrial discharges covered by Federal pretreatment requirements shall meet those limitations specified under the effluent guidelines published under Sections 304 (b) and 307 (b) of the Federal Act or the above concentrations, whichever is more stringent. Major contributing industries discharging incompatible pollutants into the public sewers shall be regulated as provided in Article [ ], Sec. 5.

e) Any waters of wastes containing odor-producing substances exceeding limits which may be established by the [Superintendent] or any local or state regulatory agencies.

f) Any radioactive wastes or isotopes of such half-life or concentration as may exceed limits in compliance with applicable state or Federal regulations.

g) Quantities of flow, concentrations or both which constitute a "slug" as defined herein.

h) Waters or wastes containing substances which are not amenable to treatment or reduction by the wastewater treatment processes employed, or are amenable only to such degree that the wastewater treatment plant effluent cannot meet the requirements of other agencies having jurisdiction over discharge to the receiving waters.

i) Any water or wastes which by interaction with other water or wastes in the public sewer system, release obnoxious gases, form suspended solids which interfere with the collection system, or create a condition deleterious to structures and treatment processes.

Sec. 5. *Authority for Control of Wastewater Discharges* – If any waters or wastes are discharged or are proposed to be discharged to the public sewers, which contain the substances or possess the characteristics enumerated in [Sec. 3 and/or 4] of this Article, and which in the judgment of the [Engineer], may have a deleterious effect upon the wastewater facilities, processes, equipment, or receiving waters, including violation of applicable water quality standards, or which otherwise create a hazard to life or constitute a public nuisance, the [Engineer] [shall, may]

a) Reject the wastes

b) Require pretreatment to an acceptable condition for discharge to the public sewers

c) Require control over the quantities and rates of discharge, and/or

d) Require payment to cover the added cost of handling and treating the wastes under the provisions of [Article (     )]

All industrial wastes discharged to the public sewers by major contributing industries shall as a minimum meet the national pretreatment standards or best practical control technology currently available for incompatible pollutants as published in Title 40 Code of Federal Regulations Part 128, unless the [Village] is committed, in its NPDES permit, to remove a specified percentage of the incompatible pollutant. In those instances the applicable pretreatment standards may be correspondingly reduced to levels determined by the [Engineer], or his duly authorized representative, or state regulatory agencies.

If the [Engineer] [requires] pretreatment or equalization of waste flows, the design and installation of the plants and equipment shall be subject to the review and approval of the [Engineer] and state regulatory agencies and subject to the requirements of all applicable codes, ordinances, and laws.

Sec. 6. *Grease and Oil Interceptors* For grease, oil, and inorganic material such as sand, grit, etc., interceptors shall be provided when in the opinion of the [Engineer], they are necessary for the proper handling of liquid wastes containing floatable grease in excessive amounts, as specified in Section 4(b), or any flammable wastes, sand, or other harmful ingredients; except that such interceptors shall not be required for private living quarters or dwelling units. All interceptors shall be of a type and capacity approved by the [Engineer], and shall be located as to be readily and easily accessible for cleaning and inspection. In the maintaining of these interceptors the owner(s) shall be responsible for the proper removal and disposal by appropriate means of the captured material and shall maintain records of the dates, and means of disposal which are subject to review by the [Superintendent]. Any removal and hauling of the collected materials not performed by the owner(s)' personnel must be performed by currently licensed waste disposal firms.

Sec. 7. *Operation of Pretreatment Facilities* Where pretreatment or flow-equalizing facilities are provided or required for any waters or wastes, they shall be maintained continuously in satisfactory and effective operation by the owner(s) at his expense.

Sec. 8. *Analyses* All measurements, tests, and analyses of the characteristics of waters and wastes to which reference is made in this ordinance shall be determined in accordance with the latest edition of "Standard Methods for the Examination of Water and Wastewater," published by the American Public Health Association. Sampling methods, location, times, durations, and frequencies are to be determined on an individual basis subject to approval by the [Superintendent].

Sec. 9. *Special Conditions* No statement contained in this article shall be construed as preventing any special agreement or arrangement between the [Village] and any industrial concern whereby an industrial waste of unusual strength or character may be accepted by the [Village] for treatment, subject to possible payment therefore by the industrial concern for subsequent treatment. Any industrial concern may appeal to the [Board of Control] any determination made by the [Engineer] in the enforcement of this ordinance.

## ARTICLE (    )

## Control of Industrial Wastes

Sec. 1. *Submission of Basic Data* – Within thirty (30) days after passage of this Ordinance, each person whose operation entails the discharge of industrial wastes to a public sewer shall prepare and file with the [Engineer] a written statement setting forth the nature of the operation contemplated or presently carried on, the amount and source of water required for use, the proposed point of discharge of said wastes into the wastewater collection system of the [Village], the estimated amount to be so discharged and a fair statement setting forth the expected bacterial, physical, chemical, and other known characteristics of said wastes. Within a reasonable time of receipt of such statement, it shall be the duty of the [Village] to make an order stating such minimum restrictions as in the judgment of the [Engineer] may be necessary to adequately guard against unlawful uses of the [Village's] wastewater system.

Sec. 2. *Extension of Time* – When it can be demonstrated that circumstances exist which would create an unreasonable burden on the person to comply with the time schedule imposed by Sec. 1 of this Article, a request for extension of time may be presented for consideration of the [Engineer]. All requests for extension of time shall be submitted in writing stating the reason for such a request. Under no circumstances shall the extension of time exceed thirty (30) days after approval of the extension by the [Engineer].

Sec. 3. *Control Manholes* – Each person discharging industrial wastes into a public sewer shall construct and maintain one or more control manholes or access points to facilitate observation, measurement and sampling of his wastes, including sanitary wastewater.

Control manholes or access facilities shall be located and built in a manner acceptable to the [Engineer]. If measuring devices are to be permanently installed they shall be of a type acceptable to the [Engineer].

Control manholes, access facilities, and related equipment shall be installed by the person discharging the waste at his expense, and shall be maintained by him so as to be in safe condition, accessible and in proper operating condition at all times. Plans for the installation of such facilities shall be approved by the [Engineer] prior to the beginning of construction.

Sec. 4. *Wastewater Volume Determination* — The volume of flow used for computing industrial waste surcharges shall be the metered water consumption of the person as shown in the records of water meter readings maintained by the [Village] except as herein provided in this section.

If the person discharging industrial wastes into the public sewers procures any part, or all, of this water from sources other than the [Village] water system, all or part of which is discharged into the public sewer, the person shall install and maintain at his expense water meters of a type approved by the [Engineer] for the purpose of determining the volume of water obtained from those other sources.

The person discharging industrial wastes into the public sewers may install and maintain at his expense metering devices for determining the volume of waste being discharged to the public sewer, from which the industrial waste surcharge would be computed. The measuring devices shall be of a type acceptable to the [Engineer].

The [Engineer] may require the installation of devices for measuring the volume of waste discharged if these volumes cannot otherwise be determined from the metered water consumption records.

Any metering device for determining the volume of waste discharged to the public sewer shall be installed, owned, and maintained by the person. Following approval and installation, such meters may not be removed without the consent of the [Engineer].

Sec. 5. *Sampling and Monitoring* — Industrial wastes discharged into the public sewers shall be subject to periodic inspection with a determination of character and concentration of said wastes. The determination shall be made as often as may be deemed necessary by the [Engineer] but in no case less than two (2) 24-hour composite samples per month. The owner shall be responsible for the collection and testing of the aforementioned samples.

Samples shall be collected in such a manner as to be representative of the composition of the wastes. The sampling shall be accomplished by the use of automatic sampling equipment capable of collecting composite samples.

Access to sampling locations shall be granted to the [Engineer] or his authorized representative at all times. Every care shall be exercised in the collection of samples to insure their preservation in a state comparable to that at the time the sample was taken.

Sec. 6. *Analyses* – Laboratory procedures used in the examination of industrial wastes shall be those set forth in the latest edition of "Standard Methods." However, alternative methods for certain analyses of industrial wastes may be used subject to mutual agreement between the [Engineer] and the person.

Determination of the character and concentration of the industrial wastes shall be made by the person responsible for the discharge, or his qualified agent as approved by the [Engineer]. The results of the analyses shall be reported to the [Village] on a monthly basis on forms provided by the [Village]. The [Village] shall make its own analyses on the wastes and these determinations shall be binding as a basis for charges, except under circumstances in the following paragraph.

In case the analyses performed by the industry and the [Village] result in substantially different values, an effort shall be made by the industry to collect samples at the same time the [Village] collects its own samples. The results of the analyses on the samples collected by the [Village] and the industry shall be compared using the same testing procedures as outlined in the latest edition of "Standard Methods" and the differences negotiated.

## ARTICLE (     )

### Revenue Schedule

Included within the Article discussing revenue rates, the following section should be included:

Sec. (     ) All persons discharging industrial wastewater into the public sewers as determined under the provisions of this Ordinance shall be subject to surcharges determined monthly solely on the basis of the following formula:

$$P = [A] \times B.O.D. + [B] \times S.S.$$

P = monthly surcharge.

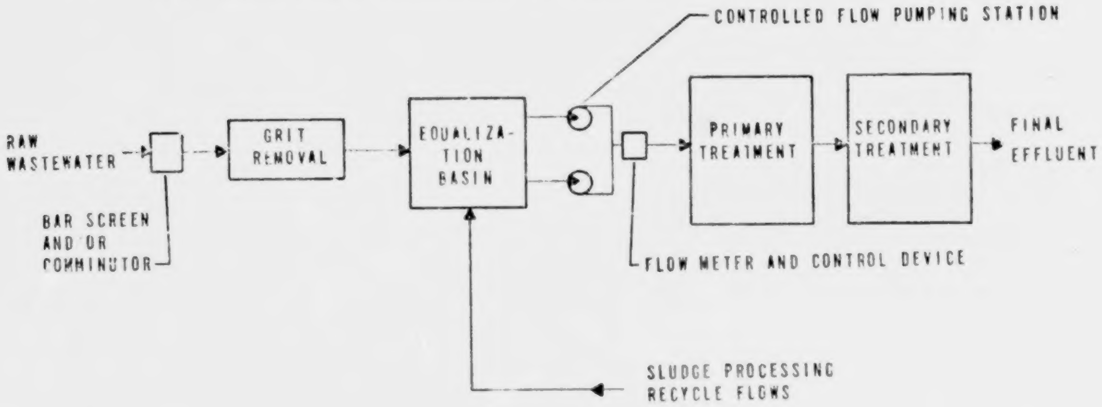
BOD = pounds of biochemical oxygen demand per month in excess of [300] mg/l concentration in the wastewater

SS = pounds of suspended solids per month in excess of [300] mg/l concentration.

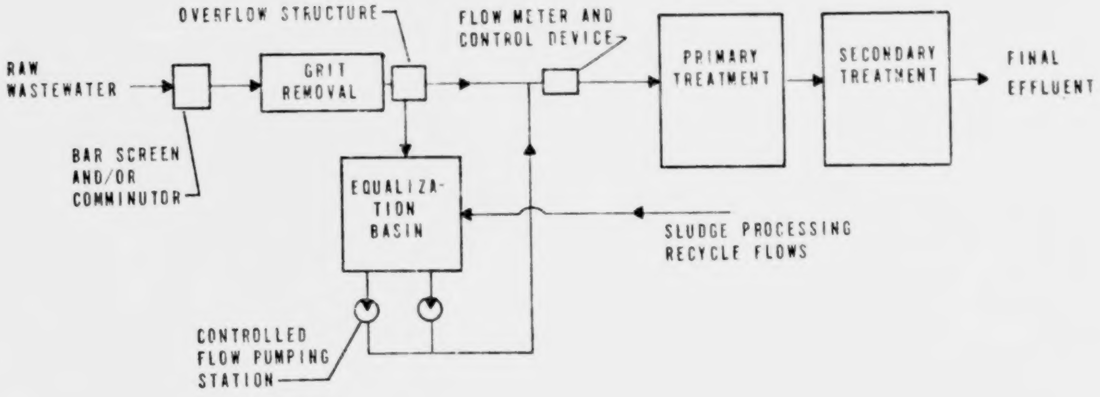
In the above formula A and B refer to the total expenditures per pound of BOD and suspended solids, respectively, to collect, convey and treat the wastewater. This information could be supplied by the Engineer or Superintendent.

Reproduced from EPA "Process Design Manual for Upgrading Existing Wastewater Treatment Plants". Technology Transfer, October, 1974, Chapter 3.

## SCHEMATIC FLOW DIAGRAMS OF EQUALIZATION FACILITIES


CONTROLLED FLOW PUMPING STATION
RAW WASTEWATER
GRIT REMOVAL
EQUALIZATION BASIN
PRIMARY TREATMENT
SECONDARY TREATMENT
FINAL EFFLUENT
BAR SCREEN AND OR COMMINUTOR
FLOW METER AND CONTROL DEVICE
SLUDGE PROCESSING RECYCLE FLOWS

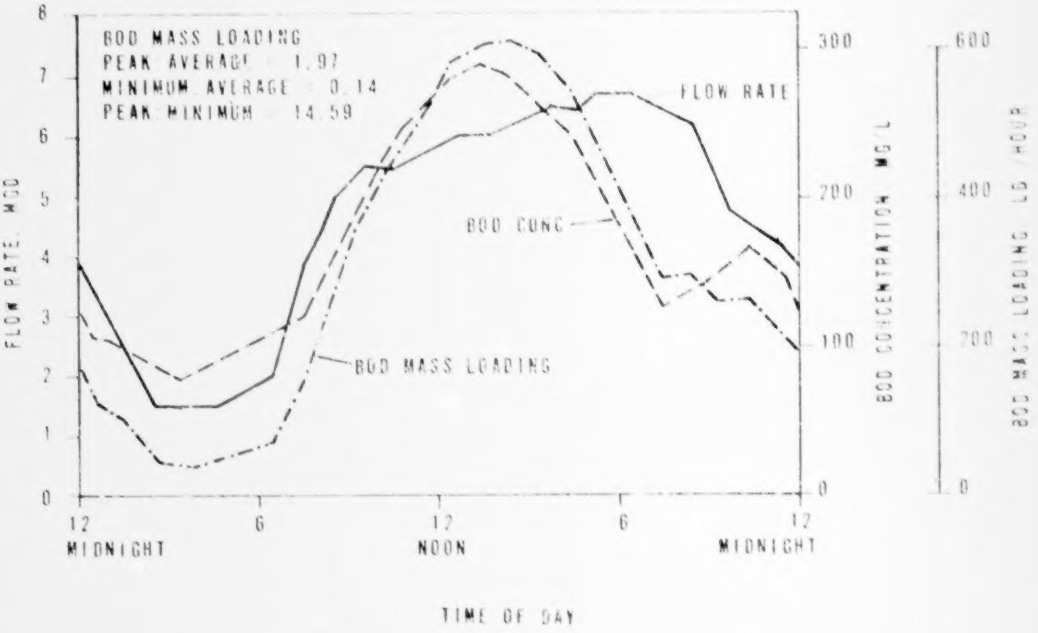
3-1a IN-LINE EQUALIZATION


OVERFLOW STRUCTURE
FLOW METER AND CONTROL DEVICE
RAW WASTEWATER
GRIT REMOVAL
PRIMARY TREATMENT
SECONDARY TREATMENT
FINAL EFFLUENT
BAR SCREEN AND/OR COMMINUTOR
EQUALIZATION BASIN
SLUDGE PROCESSING RECYCLE FLOWS
CONTROLLED FLOW PUMPING STATION

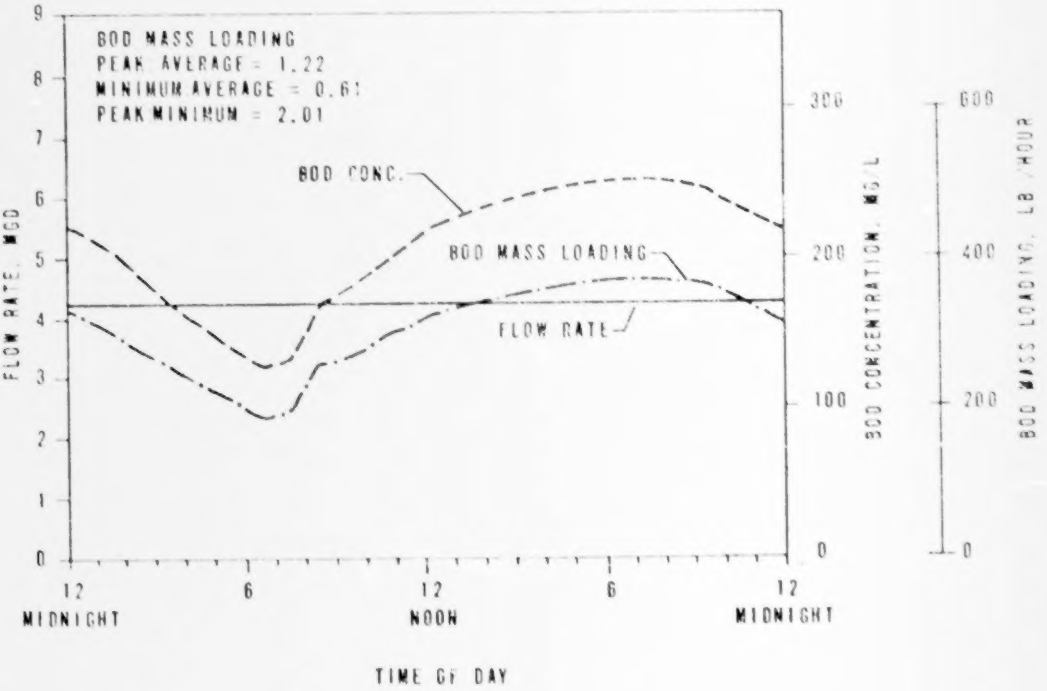
3-1b SIDE-LINE EQUALIZATION

Reproduced from EPA "Process Design Manual for Upgrading Existing Wastewater Treatment Plants". Technology Transfer, October, 1974, Chapter 3.

## RAW WASTEWATER FLOW AND BOD VARIATION BEFORE EQUALIZATION



## RAW WASTEWATER FLOW AND BOD VARIATION AFTER EQUALIZATION



## Information Regarding Normal Operations of a Primary Sedimentation

### TABLE 1 – RAW SLUDGE CHARACTERISTICS

1. Physical Texture
    a. Non-uniform
    b. Lumpy
2. Color
    a. Fresh sludge – brownish in color
    b. Septic sludge – dark grey or black
3. Density
    a. Average solids content of 3 – 8%
4. Odor
    a. Normal domestic sludge will have a slight tarry odor
    b. Septic sludge will have an offensive odor
5. Volatile Matter
    a. Average range 70 – 80% of total dry solids
6. pH
    a. Average – 6.0
    b. Range – 5.5 – 6.5
7. Total Alkalinity
    a. Average 650 mg/l
    b. Range 300 – 1,000 mg/l
8. Sludge Volume
    a. Average 250 – 350 $ft^3$/MG
    b. Range 70 – 700 $ft^3$/MG
9. Grease Content
    a. Average 15 – 20 mg/l
10. Drainability on Sand Beds
    a. Poor
11. Digestibility
    a. Normally good

### RELATIONSHIP OF PRIMARY TREATMENT TO OTHER PROCESSES

1. Will remove 35 – 40% BOD load
2. Will remove 50 – 70% suspended solids
3. Will remove 80 – 99% settleable solids
4. Will remove 90 – 94% grease
5. Will buffer shock load
6. Will increase efficiency of secondary treatment processes

## TROUBLESHOOTING GUIDE – PRIMARY TREATMENT

1. Problem: Gassy Floating Sludge

| Cause | Prevention | Correction |
|---|---|---|
| Sludge decomposing in tank and buoyed to surface | Remove more sludge more completely or frequently | 1. Operate mechanical scrapers for longer periods or continuously<br>2. Repair or replace broken or warped wooden flights<br>3. Remove sludge from hoppers more completely by gravity withdrawal or pumping for longer periods or at slower rates<br>4. Where sludge clings to inclined surfaces, remove by squeegeeing solids to sludge hopper |

2. Problem: Septic wastewater; black & odorous.

| Cause | Prevention | Correction |
|---|---|---|
| Flat grades in collection system, improper operation of lift stations, heavy industrial waste, shock loads from commercial haulers, digestor supernatant, or improper solids withdrawal from unit. | 1. Maintain correct velocities in collection lines by a flushing program. | 1. Pre-aerate wastes. |
| | 2. Inspect lift stations daily for proper operation. | 2. Chlorinate in collection system ahead of treatment plant or ahead of sedimentation tank to delay or reduce decomposition of wastewater. |
| | 3. Industrial plants and commercial haulers should provide pretreatment of strong wastes. | 3. Improve hydraulics of wastewater system to reduce accumulations of solids. |
| | 4. Digestor supernatant should receive further treatment before entering head of plant. | 4. Digestor supernate: cure<br>a. correct or improve sludge digestion to produce improved quality supernate<br>b. reduce rate of withdrawal of supernatant to sedimentation tank<br>c. presettle or elutriate the supernatant<br>d. select better quality of supernatant from another zone or delay withdrawal until quality improves<br>e. discharge a portion or all of supernatant, until quality improves, to other points such as: sludge drying bed or supernatant aeration tank |
| | 5. Regular program of withdrawing solids from unit. | 5. Systematic program of sludge removal from sedimentation unit. |

3. Problem: Excessive Sedimentation in Inlet Channel

| Cause | Prevention | Correction |
|---|---|---|
| Velocity too low for cross sectional area of channel at current flow rate | Reduce cross sectional area of channel by installing inner wall of suitable material along one wall of channel | Agitate with air, water or other means to prevent decomposition |

4. Problem: Excessive Solids or Growths on Surfaces and Weirs

| Cause | Prevention | Correction |
|---|---|---|
| Accumulation of wastewater solids and resultant plant growth. | Frequent and thorough scrubbing of all surfaces in contact with wastewater. | Frequent and thorough scrubbing of all surfaces in contact with wastewater. |

5. Problem: Intermittent Flow or Surging

| Cause | Prevention | Correction |
|---|---|---|
| High intermittent pumping rates | 1. Adjust pump controls so that larger pumps cut in only at maximum flows<br>2. Reduce infiltration/inflow in collection system | Install or adjust baffles to reduce inlet velocities and to produce better flow distribution across entire width of tank. |

6. Problem: Broken Scraper Chains or Shear Pin Failures

| Cause | Prevention | Correction |
|---|---|---|
| Excessive load on sludge scraper | 1. Periodically dewater tank and examine all metal parts for defects and wear<br>2. Replace defective and worn parts | 1. Operate collector mechanism continuously or for longer periods and/or pump sludge more often<br>2. Operate grit chamber or reduce entrance of grit tank if grit accumulation is substantial<br>3. Remove or break up ice formation on walls and surfaces |

7. Problem: Sludge Hard to Remove from Hopper

| Cause | Prevention | Correction |
|---|---|---|
| 1. High content of grit or other easily compacted material.<br>2. Withdrawal lines with velocity too low or too high. | Reduce grit content by installing grit chamber or locating and correcting sources of grit entering the wastewater system. | 1. Loosen compacted material manually or by pressure with air or liquid.<br>2. Backflush clogged pipelines<br>3. Pump sludge more frequently<br>4. Revise sludge piping<br>5. If piping permits, return digested sludge back to clarifier hopper. |

8. Problem: Excessive Corrosion on Unit

| Cause | Prevention | Correction |
|---|---|---|
| Septic wastewater or excessive amount of corrosive wastewater gases. | 1. Keep all surfaces which come in contact with corrosive wastewater or gases coated with a quality paint (lead paint should not be used where contact with hydrogen sulfide gas may be encountered).<br>2. Regular preventive maintenance.<br>3. Proper operation and maintenance of this unit.<br>4. Install sacrificial anodic protection. | Replace worn out and damaged equipment where appropriate. |

## REFERENCES – PRETREATMENT – PRIMARY TREATMENT

Federal Guidelines Pretreatment of Pollutants Introduced Into Publicly Owned Treatment Works. US Environmental Protection Agency, Office of Water Program Operations, October 1973. p 167.

Process Design Manual for Upgrading Existing Wastewater Treatment Plants. US Environmental Protection Agency, Technology Transfer, October 1974. p 386.

URS Research Company, Environmental Systems Division. Procedures for Evaluating Performance of Wastewater Treatment Plants. USEPA. San Mateo, California, 1972. p 22

New England Interstate Water Pollution Control Commission. Controlling the Effects of Industrial Wastes on Sewage Treatment. Prepared by Wesleyan University, 1970.

New York State Department of Health. Manual of Instruction for Sewage Treatment Plant Operators.

Texas Water Utilities Association. Manual of Wastewater Operations. Austin, Texas, 1971

Sacramento State College Department of Civil Engineering. Operation of Wastewater Treatment Plants, Sacramento, California, 1970.

Sub-Committee on Operation of Wastewater Treatment Plants. Operation of Wastewater Treatment Plants, Manual of Practice, No. 11, Washington, D.C., 1970. p 195.

## LESSON: TRICKLING FILTERS

### Index of Notebook Materials

| | | |
|---|---|---|
| TF-1 thru 5 | Flow diagrams relating to upgrading trickling filter plants.* | Referred briefly by Instructor. Subdivision 1, Section III. |
| TF-6 | Answer Sheet, Troubleshooting Problem. | Used by student groups to answer problems in Subdivision 2. Used also for discussion, Subdivision 3. |
| TF-7 | References | |

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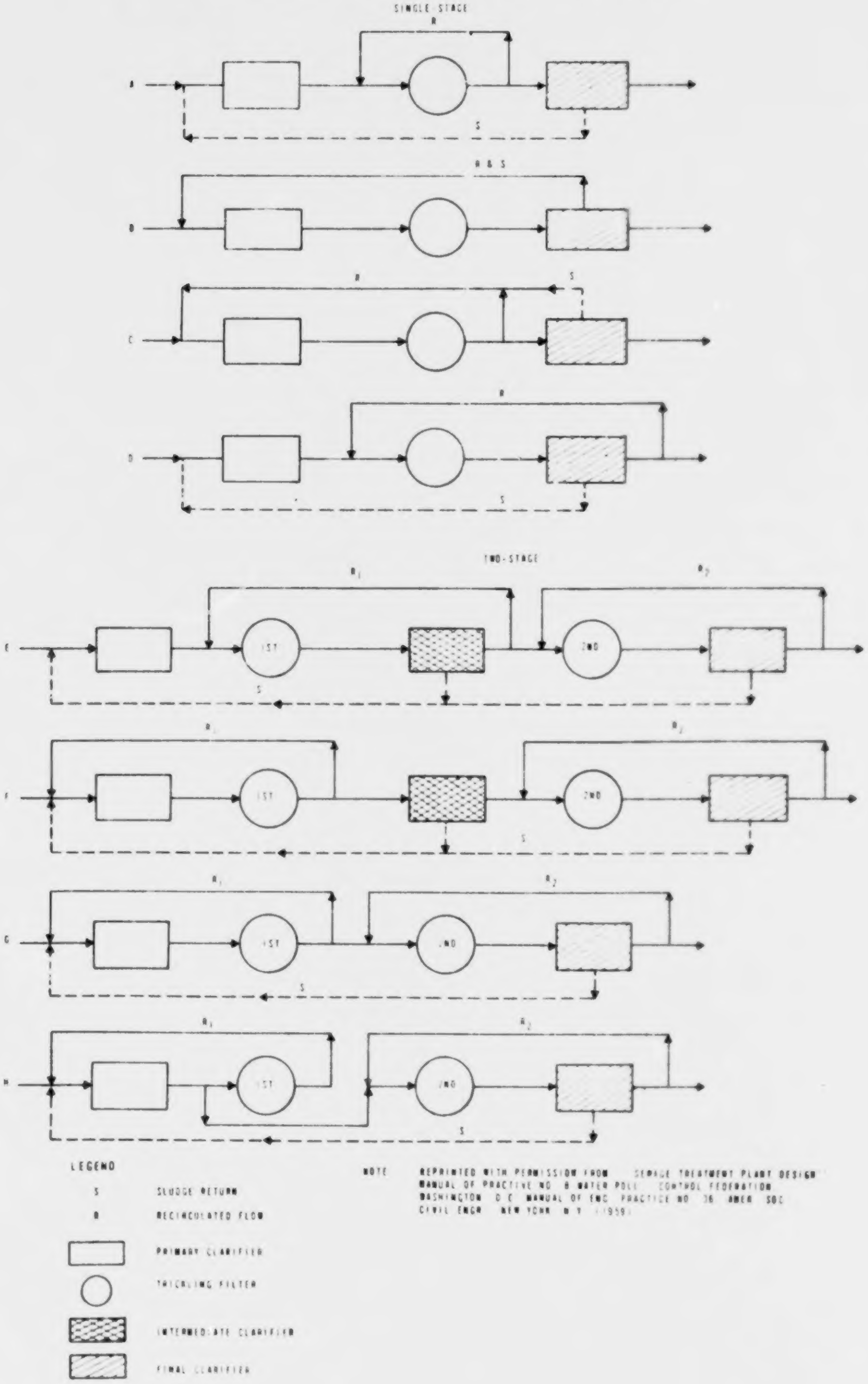
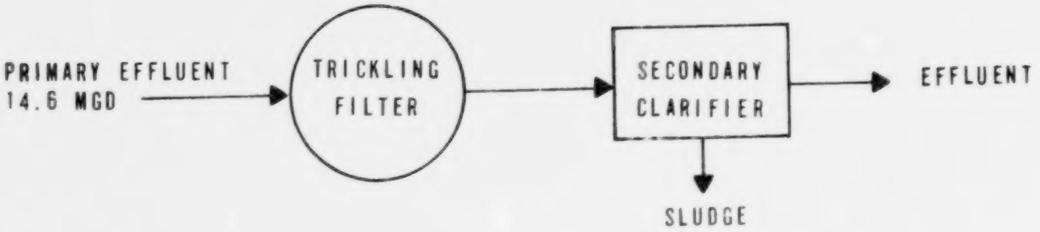
*Reproduced from EPA Manual, "Upgrading Existing Wastewater Treatment Plants," Chapter 4.

# COMMON FLOW DIAGRAMS FOR SINGLE AND TWO-STAGE HIGH-RATE TRICKLING FILTERS (2)

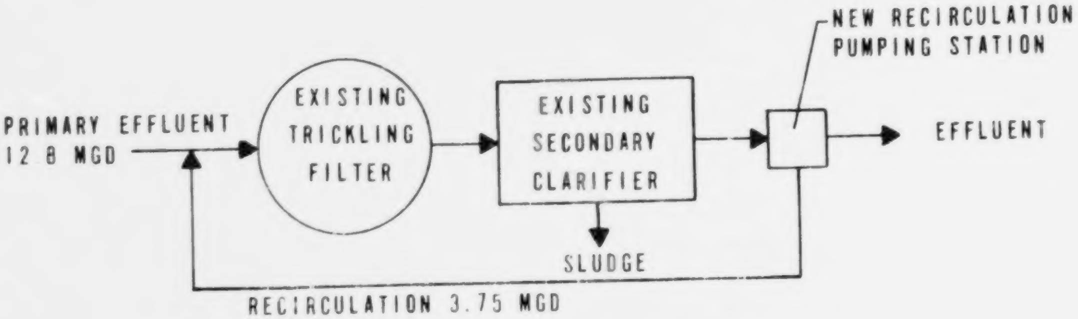

SINGLE STAGE
R
A
S
R & S
B
R
S
C
R
D
S
TWO-STAGE
R1
R2
E
1ST
2ND
S
R1
R2
F
1ST
2ND
S
R1
R2
G
1ST
2ND
S
R1
R2
H
1ST
2ND
S
LEGEND
S SLUDGE RETURN
R RECIRCULATED FLOW
PRIMARY CLARIFIER
TRICKLING FILTER
INTERMEDIATE CLARIFIER
FINAL CLARIFIER

NOTE REPRINTED WITH PERMISSION FROM "SEWAGE TREATMENT PLANT DESIGN" MANUAL OF PRACTICE NO. 8 WATER POLL. CONTROL FEDERATION WASHINGTON, D.C. MANUAL OF ENG. PRACTICE NO. 36, AMER. SOC. CIVIL ENGR., NEW YORK, N.Y. (1959)

# UPGRADING A SINGLE-STAGE LOW-RATE TRICKLING FILTER BY IMPROVING DISTRIBUTION

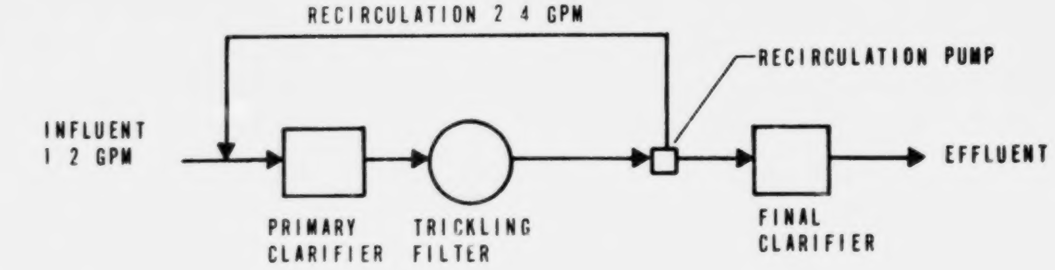

PRIMARY EFFLUENT
14.6 MGD
TRICKLING FILTER
SECONDARY CLARIFIER
EFFLUENT
SLUDGE

TREATMENT SYSTEM BEFORE UPGRADING

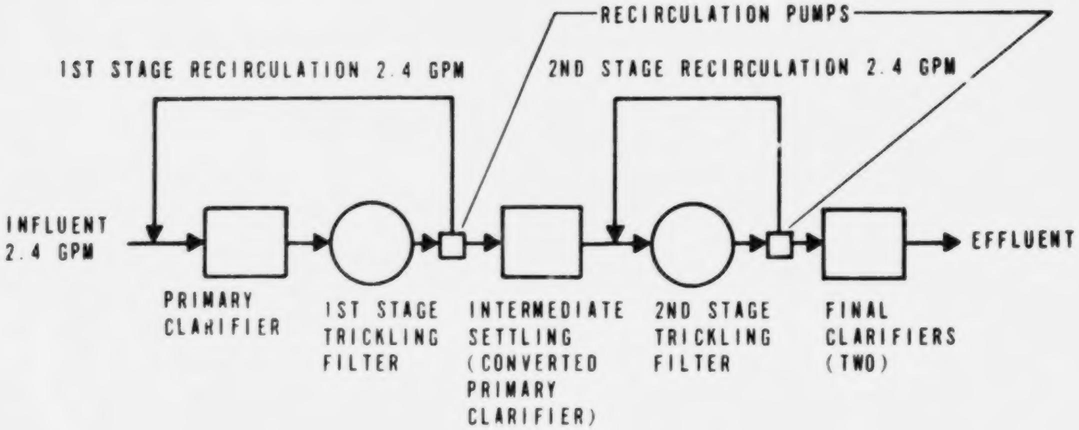

NEW RECIRCULATION PUMPING STATION
PRIMARY EFFLUENT
12.8 MGD
EXISTING TRICKLING FILTER
EXISTING SECONDARY CLARIFIER
EFFLUENT
SLUDGE
RECIRCULATION 3.75 MGD

TREATMENT SYSTEM AFTER UPGRADING

## MODIFYING A SINGLE-STAGE TRICKLING FILTER TO A TWO-STAGE FILTRATION SYSTEM

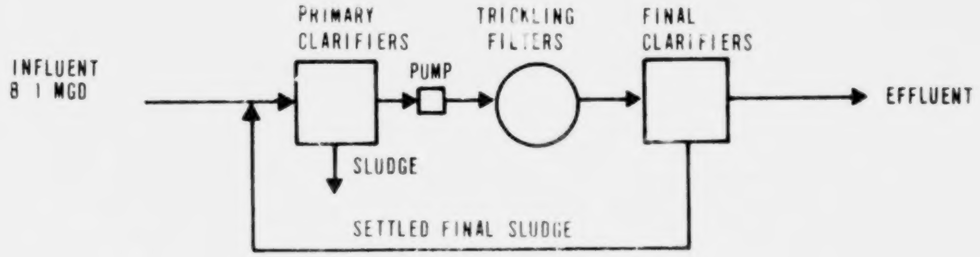

RECIRCULATION 2.4 GPM
RECIRCULATION PUMP
INFLUENT 1.2 GPM
EFFLUENT
PRIMARY CLARIFIER
TRICKLING FILTER
FINAL CLARIFIER

TREATMENT SYSTEM PERFORMING AS
SINGLE-STAGE TRICKLING FILTER SYSTEM
(ONE OF TWO DUPLICATE TRAINS)

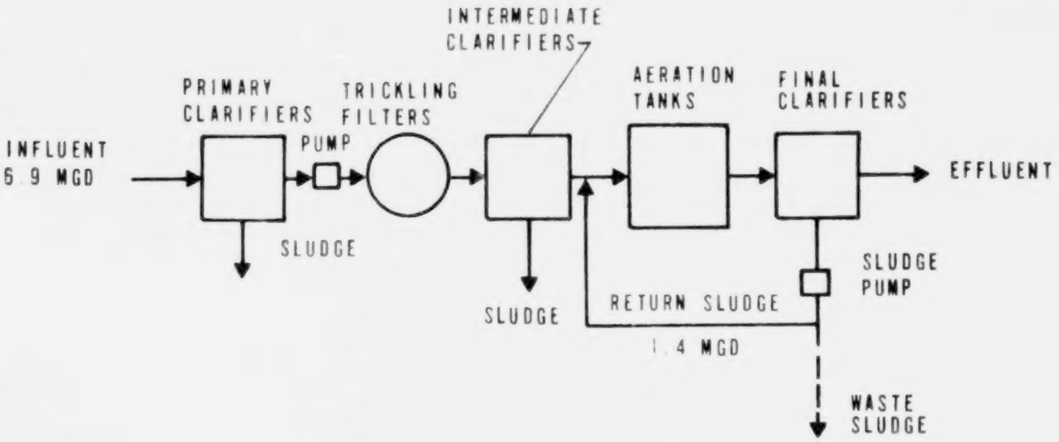

RECIRCULATION PUMPS
1ST STAGE RECIRCULATION 2.4 GPM
2ND STAGE RECIRCULATION 2.4 GPM
INFLUENT 2.4 GPM
EFFLUENT
PRIMARY CLARIFIER
1ST STAGE TRICKLING FILTER
INTERMEDIATE SETTLING (CONVERTED PRIMARY CLARIFIER)
2ND STAGE TRICKLING FILTER
FINAL CLARIFIERS (TWO)

TREATMENT SYSTEM MODIFIED TO
TWO-STAGE TRICKLING FILTER SYSTEM

# UPGRADING A SINGLE STAGE TRICKLING FILTER TO A TWO-STAGE BIOLOGICAL FILTRATION/ACTIVATED SLUDGE SYSTEM

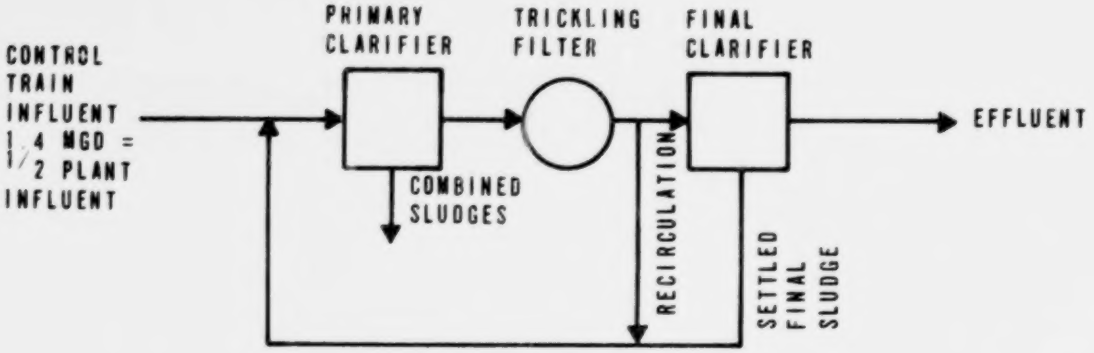

PRIMARY CLARIFIERS
TRICKLING FILTERS
FINAL CLARIFIERS
INFLUENT 8.1 MGD
PUMP
EFFLUENT
SLUDGE
SETTLED FINAL SLUDGE

TREATMENT SYSTEM BEFORE UPGRADING

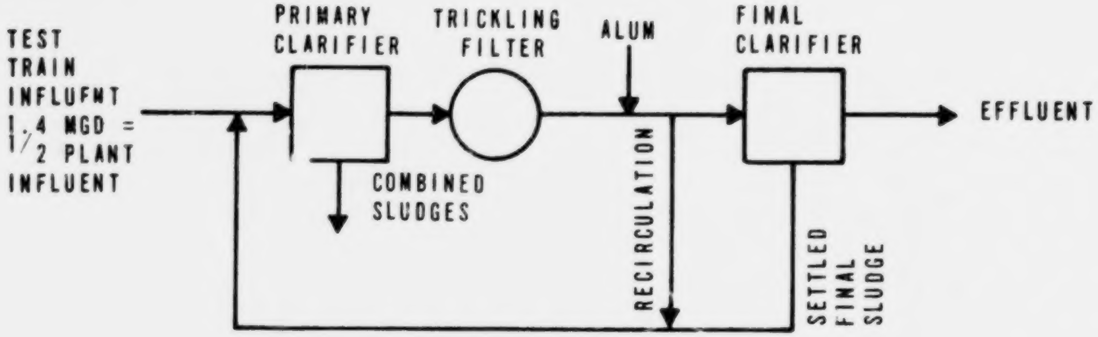

INTERMEDIATE CLARIFIERS
PRIMARY CLARIFIERS
TRICKLING FILTERS
AERATION TANKS
FINAL CLARIFIERS
INFLUENT 6.9 MGD
PUMP
EFFLUENT
SLUDGE
SLUDGE
SLUDGE PUMP
RETURN SLUDGE
1.4 MGD
WASTE SLUDGE

TREATMENT SYSTEM AFTER UPGRADING

# UPGRADING A TRICKLING FILTER SYSTEM USING CHEMICAL ADDITION FOR PHOSPHORUS REMOVAL


CONTROL TRAIN INFLUENT 1.4 MGD = 1/2 PLANT INFLUENT
PRIMARY CLARIFIER
TRICKLING FILTER
FINAL CLARIFIER
EFFLUENT
COMBINED SLUDGES
RECIRCULATION
SETTLED FINAL SLUDGE

TRICKLING FILTER TRAIN WITHOUT CHEMICAL ADDITION


TEST TRAIN INFLUENT 1.4 MGD = 1/2 PLANT INFLUENT
PRIMARY CLARIFIER
TRICKLING FILTER
ALUM
FINAL CLARIFIER
EFFLUENT
COMBINED SLUDGES
RECIRCULATION
SETTLED FINAL SLUDGE

TRICKLING FILTER TRAIN WITH CHEMICAL ADDITION

## ANSWER SHEET

### Troubleshooting Problem – Trickling Filters

GROUP NUMBER ____________ DISCUSSION LEADER

PROBLEM NUMBER

A. STATEMENT OF PROBLEM

B. LIKELY CAUSES

C. EXPECTED EFFECTS AND SYMPTOMS

D. PROPOSED METHODS OF CORRECTION

## REFERENCES TRICKLING FILTERS

Process Design Manual for Upgrading Existing Wastewater Treatment Plants. U.S. EPA Technology Transfer, October, 1974.

Procedural Manual for Evaluating the Performance of Wastewater Treatment Plants. U.S. EPA URS Research Company.

Clark, J.W., W. Viessman, Jr., and M.J. Hammer. Water Supply and Pollution Control. International Textbook Company, 1971, 2nd Edition.

Manual of Wastewater Operations. Texas Water Utilities Association. Lancaster Press, Inc. 1971, 4th Edition.

Manual of Instruction for Sewage Treatment Plant Operators. New York State Department of Health. Distributed outside of New York State by Health Education Service, P.O. Box 7283, Albany, New York 12224.

Operation of Wastewater Treataent Plants. Water Pollution Control Federation No. 11, Water Pollution Control Federation. 1970.

Operation of Wastewater Treatment Plants. A Field Study Training Program. California State University, Sacramento.

Wastewater Engineering. Collection, Treatment, Disposal. Metcalf & Eddy, Inc. McGraw Hill Book Company. 1972.

Hanumanulu, V., Effect of Recirculation on Deep Trickling Filter Performance. Journal Water Pollution Control Federation, 41, 1803, 1969.

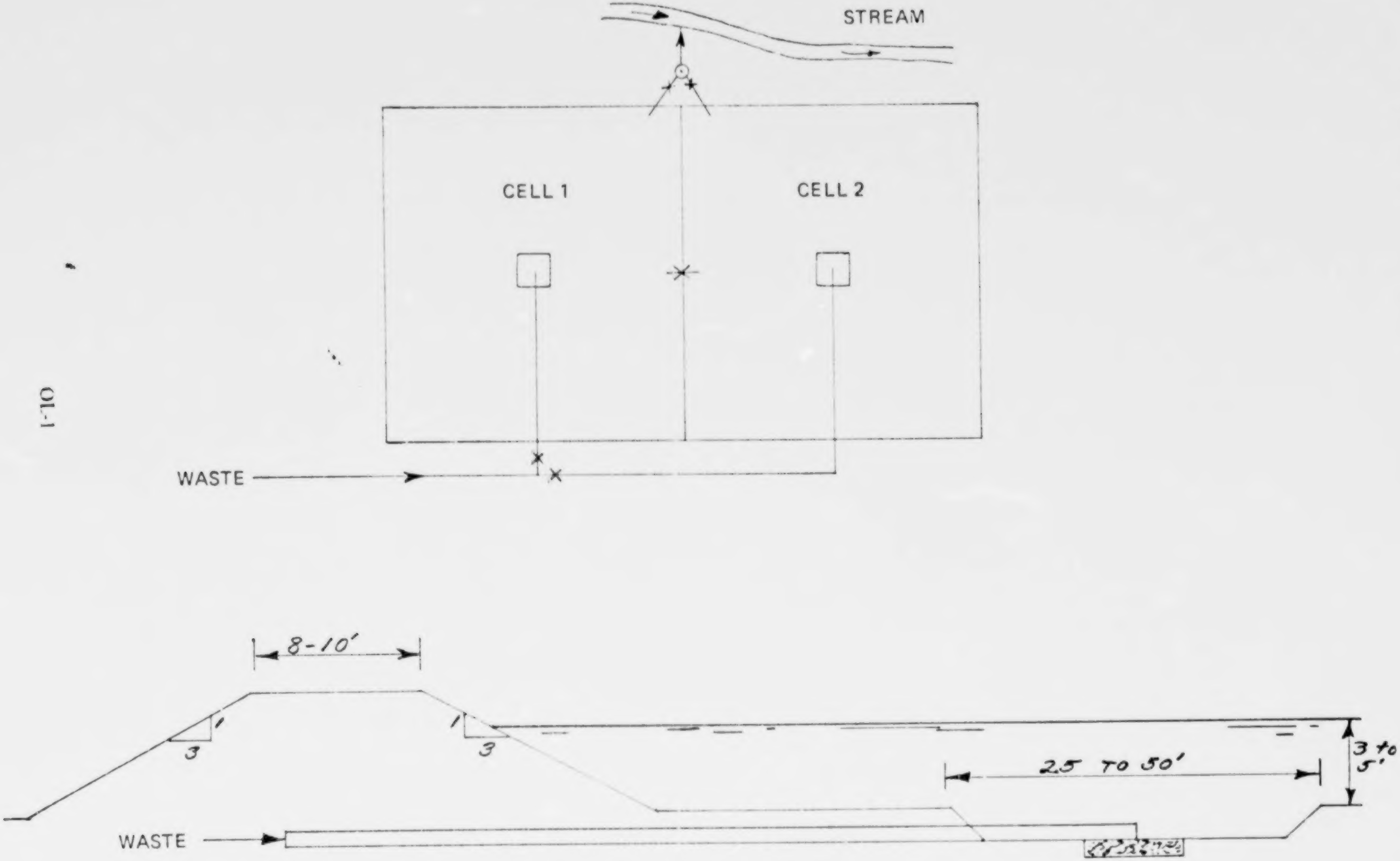
Hawkes, H.A., and R.N. Shephard. The Effect of Dosing Frequency on the Seasonal Fluctuations and Vertical Distribution of Solids and Grazing Fauna in Sewage Percolating Filters. Water Research, 6, 721, 1972.

DeRuitar, H., Control of Psychoda Flies. Water and Sewage Works, Volume 107, No. 6, 211, 1960.

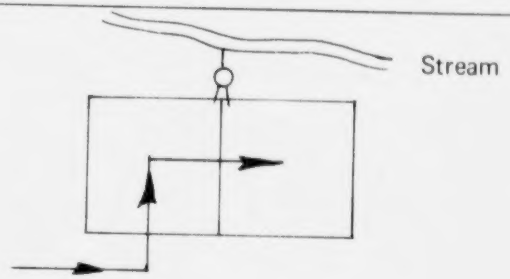
## LESSON: OXIDATION LAGOONS

### Index of Notebook Materials

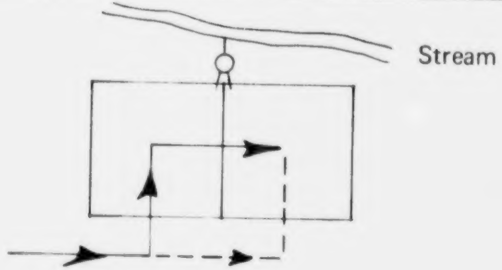
| PAGES | MATERIAL | USE IN LESSON |
|---|---|---|
| OL – 1 | Schematic Plan and Section of typical lagoon | Background for Subdivision I |
| OL – 2 | Seasonal Flow Patterns Two Stage Lagoons | Reference by Instructor Subdivision I, Section III |
| OL – 3 | References | |


STREAM
CELL 1
CELL 2
WASTE
8-10'
1
3
1
3
25 TO 50'
3 to 5'
WASTE

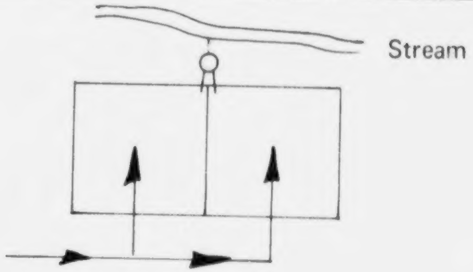
SCHEMATIC PLAN AND SECTION OF TYPICAL WASTE STABILIZATION LAGOON



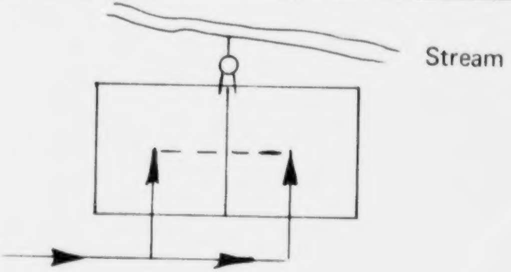
SUMMER (July, August, September)
1. Flow Pattern: Series
2. Depth: 5 ft



FALL (October, November, December)
1. Flow Pattern:
    Oct., Nov. – Series
    Dec. – Parallel
2. Depth: Lower to 2½ – 3 ft
3. Effluent: Shut off (Dec.)



WINTER (January, February, March)
1. Flow Pattern: Parallel
2. Effluent: Off
(Hold All Flow)



SPRING (April, May, June)
1. Flow Pattern:
    Apr., May – Parallel
    June – Series
2. Depth: 5 ft

SEASONAL SEQUENCING OF FLOW PATTERN IN TWO-STAGE WASTE STABILIZATION LAGOONS

## REFERENCES – OXIDATION LAGOONS

URS Research Company. Procedures for Evaluating Performance of Wastewater Treatment Plants. U.S. Environmental Protection Agency.

O'Brien, W.J., R.E. McKinney, M.D. Turvey. Two Methods for Algae Removal from Oxidation Pond Effluents. Water and Sewage Works. March, 1973. pp 66-73.

New York State Health Department. Manual of Instruction of Sewage Plant Operators.

U.S. Public Health Service, Region VI. Waste Stabilization Lagoons Design, Construction and Operator Practices Among Missouri Basin States. January 21, 1960.

U.S. Environmental Protection Agency, Technology Transfer. Upgrading Lagoons. August, 1973.

Goswami, S.R., W. H. Busch. Three Stage Ponds Earn Plaudits. Water and Wastes Engineering. April, 1972. pp 40-43.

U.S. Environmental Protection Agency. Supplement to Federal Guidelines: Design, Operation and Maintenance of Wastewater Treatment Facilities. Wastewater Treatment Ponds. Technical Bulletin. EPA 430/9-70-011. March, 1974.

Division of Sanitary Engineering, South Dakota State Department of Health. Operation and Maintenance of Stabilization Ponds.

Matthew, F.L., Operation and Maintenance of Aerobic Stabilization Ponds. Water and Wastes Engineering. July, 1968. p 64.

Brinck, C. W. Operation and Maintenance of Sewage Lagoons. Water and Sewage Works. October, 1972.

Minnesota Pollution Control Agency. Stabilization Pond Operation and Maintenance Manual. 1975.

## LESSON: LABORATORY PRACTICES

### Index of Notebook Materials

| PAGES | MATERIAL | USE IN LESSON |
|---|---|---|
| LP – 1 thru 4 | Estimated Unit Process Sampling and Testing Needs, Appendix A* | Reference by Instructor Subdivision 1, Section II These pages are used in the presentation of Section IIC |
| LP – 5 | Recommended Means of Preserving Samples | Reference by Instructor Subdivision 1, Section II |
| LP – 6 and 7 | Manpower Estimate Charts, Appendix D* | Reference by Instructor Subdivision 2, Section II |
| LP – 8 thru 13 | Laboratory Equipment Troubleshooting | Reference by Instructor Subdivision 2, Section III |
| LP – 14 thru 16 | Estimated Floor Space, Bench Area and Cabinet Volume, Appendix C* | Reference by Instructor Subdivision 2, Section III |
| LP - 17 | References | |

* Denotes materials reproduced from EPA Manual, "Estimating Laboratory Needs for Municipal Wastewater Treatment Facilities"

# ESTIMATED UNIT PROCESS SAMPLING AND TESTING NEEDS

## PRIMARY CLARIFICATION

|  |  | PLANT SIZE (MGD) | TEST FREQUENCY | LOCATION OF SAMPLE | METHOD OF SAMPLE | REASON FOR TEST |
|---|---|---|---|---|---|---|
| SUGGESTED MINIMUM | BOD | ALL | 2/W | I<br>E | 24C | H |
|  | SUSPENDED SOLIDS | ALL | 3/W | I<br>E | 24C | H |
|  | SETTLEABLE SOLIDS | ALL | 3/W | I<br>E | G | H |
|  | TOTAL SOLIDS | <1 | 3/W | S | G | P |
|  | SLUDGE VOLUME LAB CENTRIFUGE | >1 | 3/D | S | G | P |
|  | TOTAL SOLIDS | >1 | 1/W | S | G | P |
|  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |
| OPTIONAL | COD | >15 | 1/W | I<br>E | 24C | H |
|  | VOLATILE SUSPENDED SOLIDS | >5 | 3/W | I<br>E | 24C | H |
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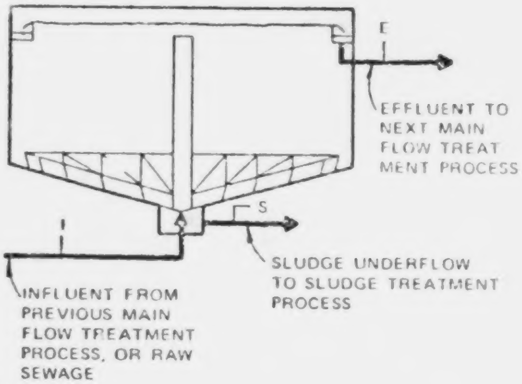
E
EFFLUENT TO NEXT MAIN FLOW TREATMENT PROCESS
S
I
SLUDGE UNDERFLOW TO SLUDGE TREATMENT PROCESS
INFLUENT FROM PREVIOUS MAIN FLOW TREATMENT PROCESS, OR RAW SEWAGE

**A. TEST FREQUENCY**

| | | | |
|---|---|---|---|
| H = HOUR | | M = MONTH | |
| D = DAY | | R = RECORD CONTINUOUSLY | |
| W = WEEK | | Mn = MONITOR CONTINUOUSLY | |

**B. LOCATION OF SAMPLE**

I = INFLUENT
E = EFFLUENT
S = SLUDGE UNDERFLOW

**C. METHOD OF SAMPLE**

24C = 24 HOUR COMPOSITE
G = GRAB SAMPLE
R = RECORD CONTINUOUSLY
Mn = MONITOR CONTINUOUSLY

**D. REASON FOR TEST**

H = HISTORICAL KNOWLEDGE
P = PROCESS CONTROL
C = COST CONTROL

**E. FOOTNOTES:**

## ESTIMATED UNIT PROCESS SAMPLING AND TESTING NEEDS

### SECONDARY TREATMENT

|  |  | PLANT SIZE (MGD) | TEST FREQUENCY | LOCATION OF SAMPLE | METHOD OF SAMPLE | REASON FOR TEST |
|---|---|---|---|---|---|---|
| SUGGESTED MINIMUM | BOD | ALL | 2/W | I | 24C | P |
|  | SUSPENDED SOLIDS | ALL | 5/W | E | 24C | P |
|  | SETTLEABILITY | ALL | 5/W | E | G | P |
|  | pH | ALL | 5/W | P | G | P |
|  | DO | ALL | 5/W | P | G | P |
|  | AIR INPUT(1) | ALL | R | B | R | H |
|  | $NH_3$-N(2) | ALL | 1/D | I(3) | 24C | H |
|  | ORG N(2) | ALL | 1/D | I(3) | 24C | H |
|  | $NO_3$-N(2) | ALL | 1/D | I(3) | 24C | H |
|  | TOTAL-P(2) | ALL | 3/W | I(3) | 24C | H |
|  | ORTHO-P(2) | ALL | 3/W | I(3) | 24C | H |
|  | FLOW | ALL | R | RS | R | P |
| OPTIONAL | MICROSOPIC ANALYSIS | ALL | 2/W | P | G | H |
|  | $NO_3$-N | ALL | 3/W | P | G | P |
|  | TOTAL SOLIDS | >1 | 3/W | E | 24C | H |
|  | TOTAL VOLATILE SOLIDS | >1 | 3/W | E | 24C | H |
|  | COD | >5 | 2/W | I | 24C | H |
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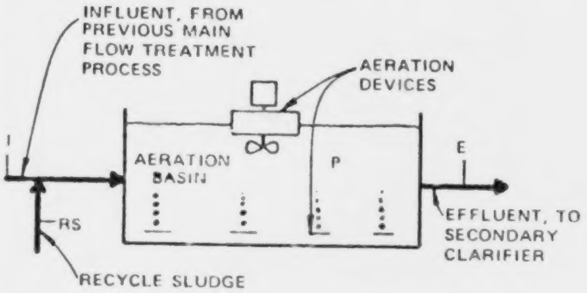
**ACTIVATED SLUDGE**


INFLUENT, FROM PREVIOUS MAIN FLOW TREATMENT PROCESS
AERATION DEVICES
I
AERATION BASIN
P
E
RS
EFFLUENT, TO SECONDARY CLARIFIER
RECYCLE SLUDGE

A. TEST FREQUENCY

H = HOUR
D = DAY
W = WEEK
M = MONTH
R = RECORD CONTINUOUSLY
Mn = MONITOR CONTINUOUSLY

B. LOCATION OF SAMPLE

I = INFLUENT
E = EFFLUENT
P = PROCESS
B = BLOWER (INCLUDE WITH PROCESS TESTING)
RS = RECYCLE SLUDGE

C. METHOD OF SAMPLE

24C = 24 HOUR COMPOSITE
G = GRAB SAMPLE
R = RECORD CONTINUOUSLY
Mn = MONITOR CONTINUOUSLY

D. REASON FOR TEST

H = HISTORICAL KNOWLEDGE
P = PROCESS CONTROL
C = COST CONTROL

E. FOOTNOTES:

1. DIFFUSED AIR ONLY
2. TO BE RUN IF PROCESS IS DESIGNED TO CONTROL THIS PARAMETER.
3. MAYBE RUN ON PLANT INFLUENT IF THIS IS INITIAL UNIT PROCESS FOLLOWING PRETREATMENT.

# ESTIMATED UNIT PROCESS SAMPLING AND TESTING NEEDS

## SECONDARY TREATMENT

| | | PLANT SIZE (MGD) | TEST FREQUENCY | LOCATION OF SAMPLE | METHOD OF SAMPLE | REASON FOR TEST |
|---|---|---|---|---|---|---|
| SUGGESTED MINIMUM | SUSPENDED SOLIDS | ALL | 3/W | I<br>E | 24C | P |
| | BOD | ALL | 2/W | E | 24C | H |
| | SETTLEABLE SOLIDS | ALL | 1/D | I<br>E | G | P |
| | TOTAL SOLIDS | <1 | 3/W | S | G | P |
| | $NH_3$-N[1] | ALL | 1/D | E | 24C | H |
| | ORG-N[1] | ALL | 1/W | E | 24C | H |
| | $NO_3$-N[1] | ALL | 1/D | E | 24C | H |
| | TOTAL-P[1] | ALL | 1/D | E | 24C | H |
| | ORTHO-P[1] | ALL | 1/D | E | 24C | H |
| | FLOW | ALL | R | WS<br>RS | R | P |
| | SLUDGE VOLUME LAB CENTRIFUGE | >1 | 3/D | S | G | P |
| | TOTAL SOLIDS | >1 | 1/W | S | G | P |
| | | | | | | |
| OPTIONAL | ALKALINITY | ALL | 1/W | 1 | 24C | P |
| | pH | ALL | 1/D | 1 | G | H |
| | TURBIDITY | >15 | Mn | | Mn | P |
| | | | | | | |
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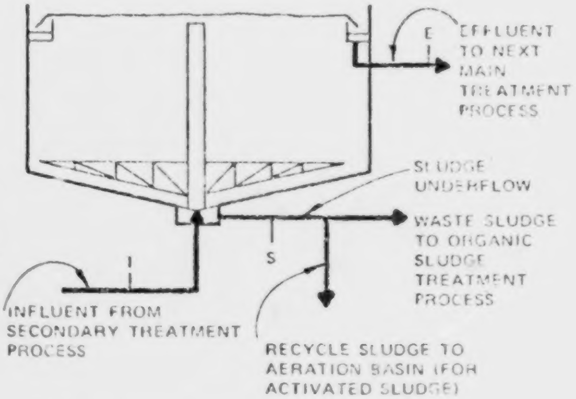
### SECONDARY CLARIFIER


E
EFFLUENT TO NEXT MAIN TREATMENT PROCESS
SLUDGE UNDERFLOW
WASTE SLUDGE TO ORGANIC SLUDGE TREATMENT PROCESS
I
S
INFLUENT FROM SECONDARY TREATMENT PROCESS
RECYCLE SLUDGE TO AERATION BASIN (FOR ACTIVATED SLUDGE)

A. TEST FREQUENCY

| | | | |
|---|---|---|---|
| H = | HOUR | M = | MONTH |
| D = | DAY | R = | RECORD CONTINUOUSLY |
| W = | WEEK | Mn = | MONITOR CONTINUOUSLY |

B. LOCATION OF SAMPLE
- I = INFLUENT
- E = EFFLUENT
- S = SLUDGE UNDERFLOW
- WS= WASTE SLUDGE
- RS= RECYCLE SLUDGE

C. METHOD OF SAMPLE
- 24C = 24 HOUR COMPOSITE
- G = GRAB SAMPLE
- R = RECORD CONTINUOUSLY
- Mn = MONITOR CONTINUOUSLY

D. REASON FOR TEST
- H = HISTORICAL KNOWLEDGE
- P = PROCESS CONTROL
- C = COST CONTROL

E. FOOTNOTES:
1. TO BE RUN IF PROCESS IS DESIGNED TO CONTROL THIS PARAMETER

## ESTIMATED UNIT PROCESS SAMPLING AND TESTING NEEDS

### SOLIDS REDUCTION

|  |  | PLANT SIZE (MGD) | TEST FREQUENCY | LOCATION OF SAMPLE | METHOD OF SAMPLE | REASON FOR TEST |
|---|---|---|---|---|---|---|
| SUGGESTED MINIMUM | TEMPERATURE | ALL | 1/D | P | G | H |
|  | pH | ALL | 1/D | P | G | H |
|  | TOTAL SOLIDS | ALL | 2/W | I<br>DS | G | H |
|  | TOTAL VOLATILE SOLIDS | >1 | 2/W | I<br>DS | G | H |
|  | DO | ALL | 3/W | P | G | P |
|  | AIR INPUT(1) | ALL | R | B | R | P<br>C |
|  | SETTLEABLE SOLIDS | ALL | 3/W | P | G | H |
|  | FLOW | ALL | R | DS | R | P |
|  | pH | ALL | (2) | S | G | H |
|  | SUSPENDED SOLIDS | ALL | (2) | S | G | H |
|  | BOD | ALL | (2) | S | G | P(3) |
|  | FLOW | ALL | R | S | R | P(3) |
|  |  |  |  |  |  |  |
| OPTIONAL | ALKALINITY | ALL | 2/W | P | G | H |
|  |  |  |  |  |  |  |
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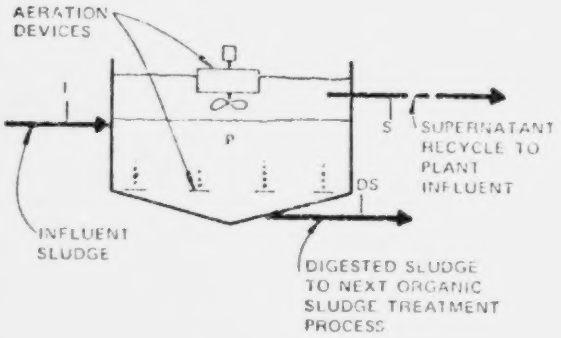
AEROBIC DIGESTION


AERATION DEVICES
I
P
S
SUPERNATANT RECYCLE TO PLANT INFLUENT
DS
INFLUENT SLUDGE
DIGESTED SLUDGE TO NEXT ORGANIC SLUDGE TREATMENT PROCESS

A. TEST FREQUENCY

H = HOUR
D = DAY
W = WEEK
M = MONTH
R = RECORD CONTINUOUSLY
Mn = MONITOR CONTINUOUSLY

B. LOCATION OF SAMPLE

I = INFLUENT
DS = DIGESTED SLUDGE
S = SUPERNATANT
P = PROCESS
B = BLOWER (INCLUDE WITH PROCESS TESTING)

C. METHOD OF SAMPLE

24C = 24 HOUR COMPOSITE
G = GRAB SAMPLE
R = RECORD CONTINUOUSLY
Mn = MONITOR CONTINUOUSLY

D. REASON FOR TEST

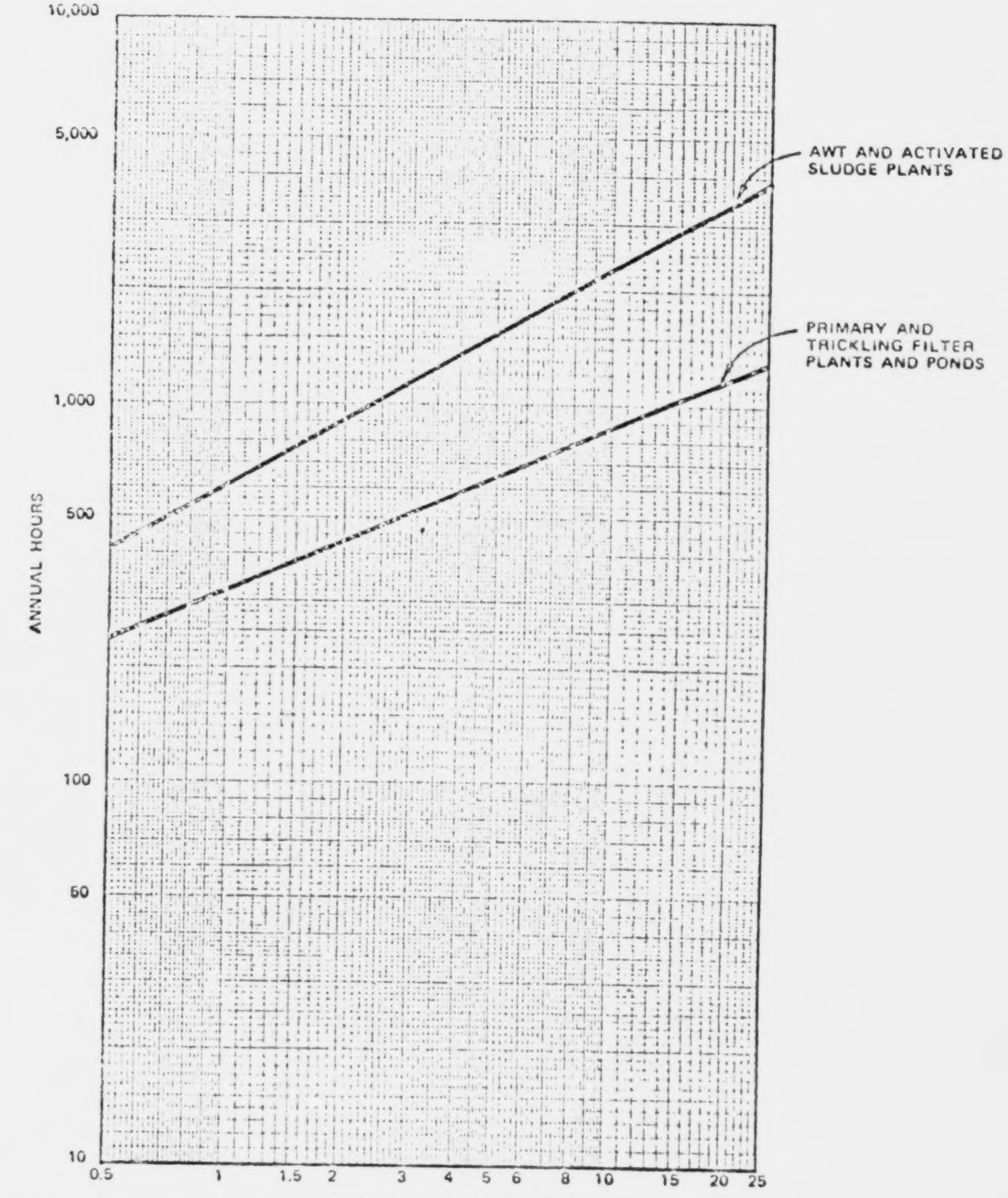
H = HISTORICAL KNOWLEDGE
P = PROCESS CONTROL
C = COST CONTROL

E. FOOTNOTES:

1. DIFFUSED AIR ONLY.
2. WHEN DRAW OFF SUPERNATANT.
3. FOR CONTROL OF PROCESS RECEIVING THIS FLOW.

## RECOMMENDED MEANS OF PRESERVING SAMPLES

| PRESERVATIVE | ACTION | APPLICABLE TO |
|---|---|---|
| $HgCl_2$ | Bacterial Inhibitor | Nitrogen forms<br>Phosphorus forms |
| Acid ($HNO_3$) | Metals solvent, prevents precipitation | Metals |
| Acid ($H_2SO_4$) | Bacterial Inhibitor | Organic samples (COD, oil and grease, organic carbon) |
|  | Salt formation with organic bases | Ammonia, amines |
| Alkali (NaOH) | Salt formation with volatile compounds | Cyanides, organic acids |
| Refrigeration | Bacterial Inhibitor | Acidity-alkalinity, organic materials, BOD, color, odor, organic phosphorus, organic nitrogen, biological organisms (coliforms, etc) |



NOTE:

INCLUDES LAB WORK DONE BY
LAB STAFF AS WELL AS OPERATORS.

BASE LABORATORY
MANPOWER ESTIMATE

| FACTOR | ADJUSTMENT | | |
|---|---|---|---|
| LEVEL OF TREATMENT | PRIMARY<br>DECREASE 20% | T/F, PONDS, A/S<br>NO CHANGE | AWT<br>INCREASE 3% PER ADDITIONAL PROCESS |
| INDUSTRIAL WASTES | NONE OR CONSTANT FLOW<br>NO CHANGE | SEASONAL FLOW<br>NO CHANGE | ERRATIC FLOW<br>INCREASE 10% |
| AUTOMATIC SAMPLERS | NONE<br>INCREASE 10% | AT INFLUENT AND EFFLUENT<br>DECREASE 5% | THRU-OUT PLANT<br>DECREASE 2% PER POINT SAMPLED IN ADDITION TO INFLUENT AND EFFLUENT* |
| UTOMATIC MONITORS AND RECORDING | NONE<br>NO CHANGE | PROVIDED<br>DECREASE 2% PER PARAMETER MONITORED* | |
| OFF PLANT LAB WORK | NONE<br>NO CHANGE | FOR RECEIVING WATER<br>DECREASE 10% | FOR ENTIRE PLANT<br>DECREASE 100% |
| LEVEL OF TRAINING | CERTIFICATION REQUIRED<br>NO CHANGE | CERTIFICATION NOT REQUIRED QUALIFIED LAB STAFF<br>NO CHANGE | CERTIFICATION NOT REQUIRED UNQUALIFIED LAB STAFF<br>INCREASE 5% |

* MAXIMUM DECREASE EQUALS 20 PERCENT

Reproduced from
best available copy.

MANPOWER ESTIMATES – TABLE OF ADJUSTMENT
FOR LOCAL CONDITIONS (TALC)

# LABORATORY EQUIPMENT TROUBLESHOOTING

Evaluation of equipment adequacy may readily be performed by comparing existing equipment capabilities to generally accepted listings of minimum and optimum equipment requirements found in Chapter III, "Estimating Laboratory Needs for Municipal Wastewater Treatment Facilities."

Should equipment deficiencies be uncovered, the inspector may advise the proper municipal official of the apparent need and recommend they discuss the matter with their consulting engineer.

1. Analytical Balance
   a. Purpose:
   precision weighing
   b. Application:
   preparation of standards, gravimetric analysis of:
      total solids, suspended solids, sludge moisture, oils and grease, etc
   c. Troubleshooting Signs:
   mounted on heavy shock-proof table
   level adjusted as necessary

2. Trip Balance
   a. Purpose:
   coarse weighing
   b. Application:
   weighing samples for MLSS, sludge wet weights, grit analysis, filter cake moisture content, preparation of chemical solutions
   c. Troubleshooting Signs:
   maintained and used in accordance with manufacturer's instructions

3. pH Meter
   a. Purpose:
   pH measurement
   b. Application:
   industrial waste, plant waste streams, electrometric determination of alkalinity, acidity and ammonia endpoints
   c. Troubleshooting Signs:
   - frequently calibrated with buffers
   - buffer solutions fresh, free of algae
   - electrodes immersed in water for storage
   - electrode tip unbroken, free of scratches
   - electrode reservoir filled
   - electrode rinsed between operations
   - samples mixed during determinations
   - sample temperature noted, meter adjusted

4. Drying Oven

a. Purpose:
controlled constant temperature drying of samples and glassware

b. Application:
determination of total, suspended, dissolved solids, sludge drying, drying of primary chemical standard reagents, drying gravimetric glassware

c. Troubleshooting Signs
- oven equipped with thermometer
- temperature controls functional
- doors fit properly to minimize heat loss
- chamber clean and free of scale
- samples arranged to prevent cross contamination
- located away from heat sensitive equipment

5. Electric Muffle Furnace

a. Purpose:
ignition of volatile substances

b. Application:
determination of volatile and fixed solids of suspended, total, activated, and digestor solids sludges. Ignition of barium sulfate precipitates in sulfate analysis

c. Troubleshooting Signs
- furnace is equipped with temperature control
- temperature indicator functional
- chamber free of ash and residues
- fumes properly exhausted
- not located near heat sensitive equipment

6. Desiccator

a. Purpose:
provide moisture free absorbent atmosphere for temporary storage of analytical powders and glassware. Ambient drying of oil and grease fractions prior to weight determination

b. Application:
drying of standard chemical powders, cooling of gravimetric test glassware and specimens prior to weighing (e.g., total solids oils and grease, sulfates, sludges)

c. Troubleshooting Signs
- desiccator is available to every lab
- used for all specimen cooling operations prior to reweighing
- doors and lids properly seal
- desiccant material is active
- desiccant replenished when indicated

7. **BOD Incubator**

a. **Purpose**
provide constant temperature, light-free environment for storage of BOD specimens

b. **Application**
BOD incubation at 20°C

c. Troubleshooting Signs
- temperature controls functional
- proper temperature maintained
- door closes and seals properly
- chamber clean and free of biological growths

8. Water Distillation Unit

a. Purpose
provide distilled water having degree of purity from 0.055 micromhos/cm to 10 micromhos/cm

b. Application
product water used in preparation of chemical solutions, BOD dilution water, bacteriology, chemical analyses, rinsing of analytical glassware

c. Troubleshooting Signs
Difficulties encountered in bacteriological and chemical tests often relate to poor quality distilled water
- storage containers have tight covers and not exposed to airborne dust, gases, fumes
- glass storage vessels of borosilicate glass
- boiler and condenser coils free of scale
- periodic cleaning to remove sediments
- produce water frequently tested for pH and conductivity to assure adequate purity
- delivery tubing free of algae and slimes

9. Deionizer

a. Purpose
production of high purity water by ion exchange rather than distillation

b. Application
same as for water distillation unit. May be used to supplement distilled water production

c. Troubleshooting Signs
- ion exchange cartridges proper type
- exchange cartridges discarded promptly when exchange capacity is exhausted
- recommended water feed rate not exceeded
- water product stored properly to avoid contamination

10. Colorimeter or Spectrophotometer

a. **Purpose:**
quantitative measurement of water quality parameters by colorimetric technique

b. **Application:**
commonly employed for phosphorus, nitrate, nitrite, hexavalent chrome, color, sulfate by turbidity method, phenols, residual chlorine, etc.

c. **Troubleshooting Signs:**
- colorimeter is delicate precision instrument and must be treated accordingly
- common replacement parts are in stock
- instrument properly calibrated prior to transmittance or absorbance readings
- glass cells kept clean and free of scratches
- filters used in accordance with operating instructions

11. Refrigerator

a. **Purpose:**
low temperature storage unit

b. **Application:**
storage and preservation of wastewater and sludge specimens usually at 4°C. Storage of unstable chemical reagents

c. **Troubleshooting Signs:**
- temperature controls functional
- proper temperature monitored frequently
- interior clean and free of biological growths
- storage capacity adequate for lab demands

12. Autoclave

a. **Purpose:**
sterilization by steam of liquids and solids

b. **Application:**
sterilization of dilution water, glassware, sample containers, growth media, related supplies necessary for bacteriological tests

c. **Troubleshooting Signs:**
- temperature and pressure controls functional
- proper time temperature for materials being sterilized
- confirmation of adequacy of sterilization by test strips, tape indicators, etc
- materials sterilized have been properly wrapped and sealed to prevent contamination
- sterilized materials properly stored to avoid contamination

13. Electric Hotplate and Heater

a. Purpose:
variable temperature heating of liquids and solids

b. Application:
preparation of analytical solutions, evaporation, concentration, hydrolysis, digestion, other analytical operations

c. Troubleshooting Signs:
- number of hotplates and heaters adequate
- temperature controls functional

14. Dissolved Oxygen Analyzer

a. Purpose:
instrumental analysis of dissolved oxygen in liquids and gases

b. Application:
analysis of dissolved oxygen, BOD testing sewage, industrial wastes, stream samples

c. Troubleshooting Signs:
- frequent and proper calibration of instrument by wet chemical or other means
- probe stored in water or moisture saturated atmosphere between testings
- probe surfaces cleaned according to manufacturer's directions
- probe electrolyte and membranes replaced as indicated
- sample velocity at probe tip maintained during determinations
- membrane replacement kit in stock

15. Bacteria Incubator

a. Purpose:
controlled constant temperature for storage and cultivation of bacteria and biological specimens

b. Application:
total coliform, fecal streptococci, other bacteriological testing

c. Troubleshooting Signs:
- temperature controls functional
- thermometer or other temperature monitor system in place and operable
- chamber clean and free of spillage and/or biological growths
- doors close and seal properly
- unit located away from temperature extremes

16. Water Bath Incubator

a. Purpose:
controlled constant temperature bath

b. Application:
fecal coliform bacteria testing, digestion of wastewater specimens, assist color development in nitrate testing

c. Troubleshooting Signs:
temperature controls functional
- thermometer or other temperature monitor system in place and operable
- chamber and bath water clean, free of rust and sediments
- adequate cover and seal to minimize evaporative losses
- bath water level maintained

17. Conductivity Meter

a. Purpose:
measurement of solution electrical conductance and resistance

b. Application:
quality control testing of distilled water, screening of water and waste specimens

c. Troubleshooting Signs:
- electrode clean and kept in distilled water between determinations
- frequent calibration against known electrolyte references
- sample temperature corrections made

18. Total Organic Carbon Analyzer

a. Purpose:
instrumental analysis of carbon fractions in solutions by combustion/infrared technique

b. Application:
rapid assay of total, inorganic, and organic carbon fractions in water and waste samples. Data may correlate with BOD and COD, and (may be) applied accordingly in treatment plant process control

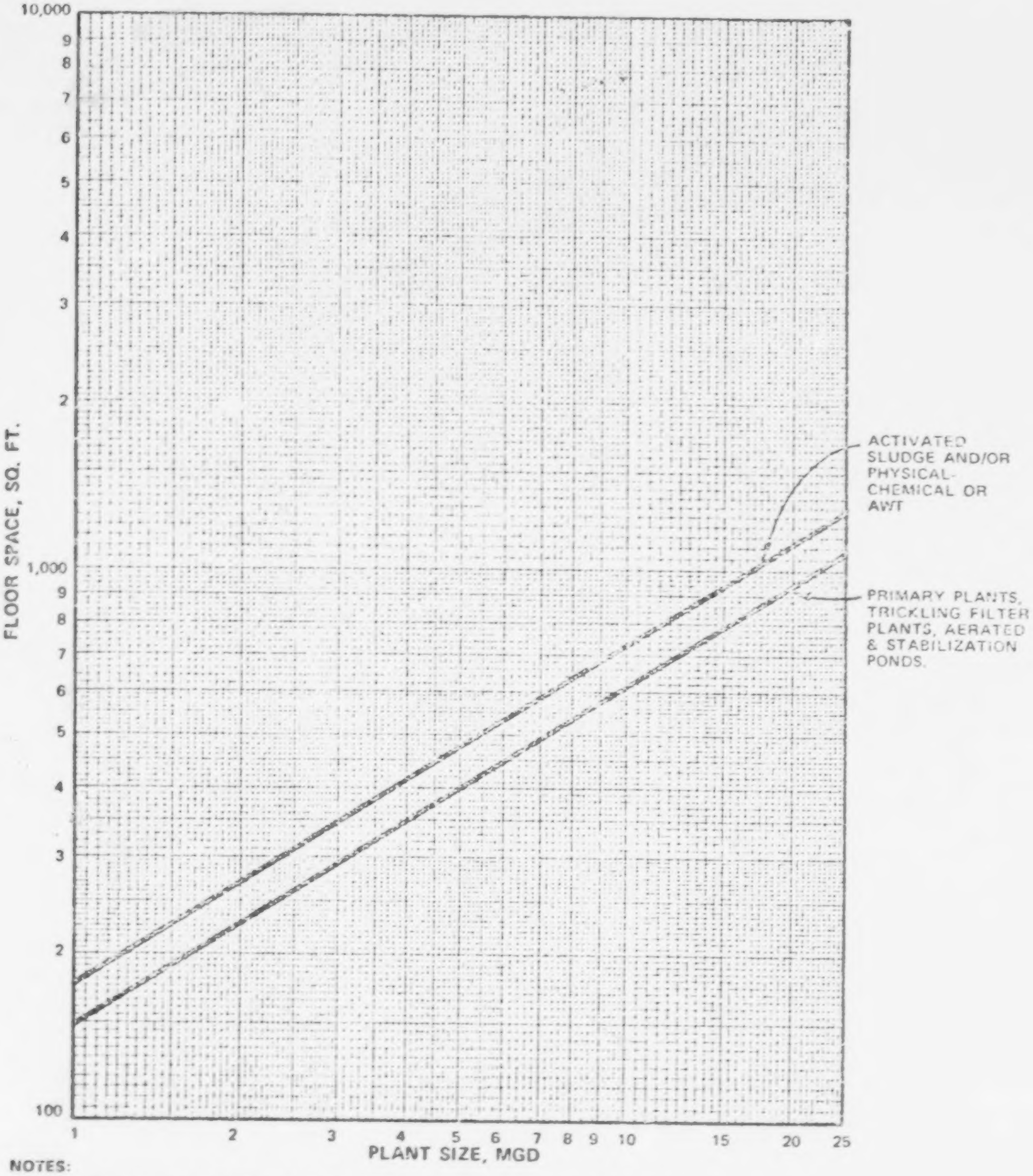
c. Troublshooting Signs:
- inspector should refer questions to qualified person due to complexity of instrument and test procedure

19. Atomic Absorption Spectrophotometer

a. Purpose:
instrumental analysis of metal ions by atomic absorption or emission technique

b. Application:
analysis of NPDES required heavy metal ions, monitoring industrial wastes for possible toxic metal ions

c. Troubleshooting Signs:
- determine instrument is properly installed with fume exhaust system
- inspector should refer questions to qualified person due to complexity of instrument and testing procedures

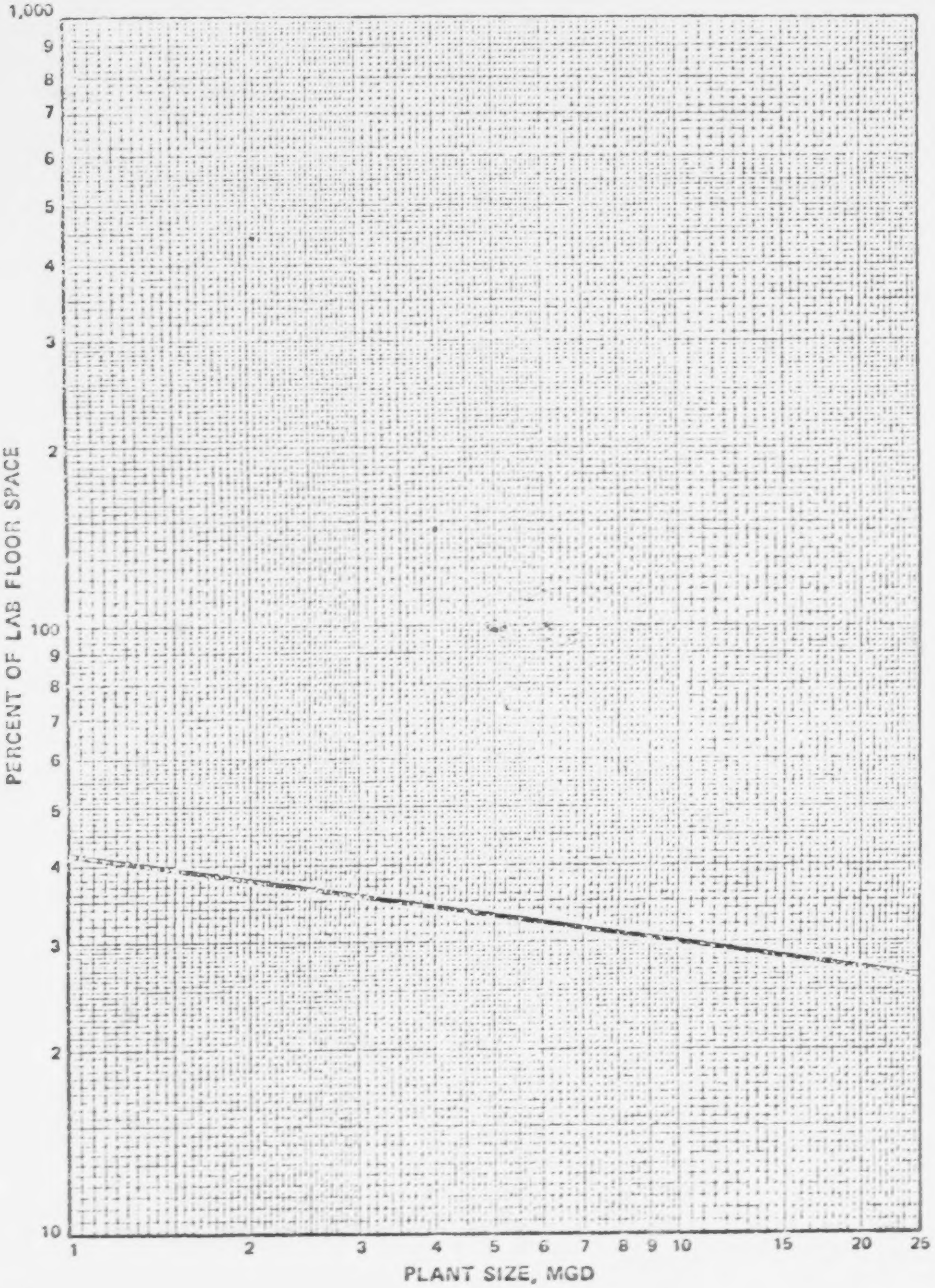


NOTES:

1. MINIMUM FLOOR SPACE REQUIRED FOR PLANTS LESS THAN 1 MGD IS 180 SQ. FT. FOR ACTIVATED SLUDGE, PHYSICAL-CHEMICAL, AND AWT PLANTS, AND 150 SQ. FT. FOR PRIMARY, TRICKLING FILTER, AND POND TYPE PLANTS.
2. INCLUDES SPACE FOR CONDUCTING LABORATORY ADMINISTRATIVE DUTIES.

FIGURE C–1

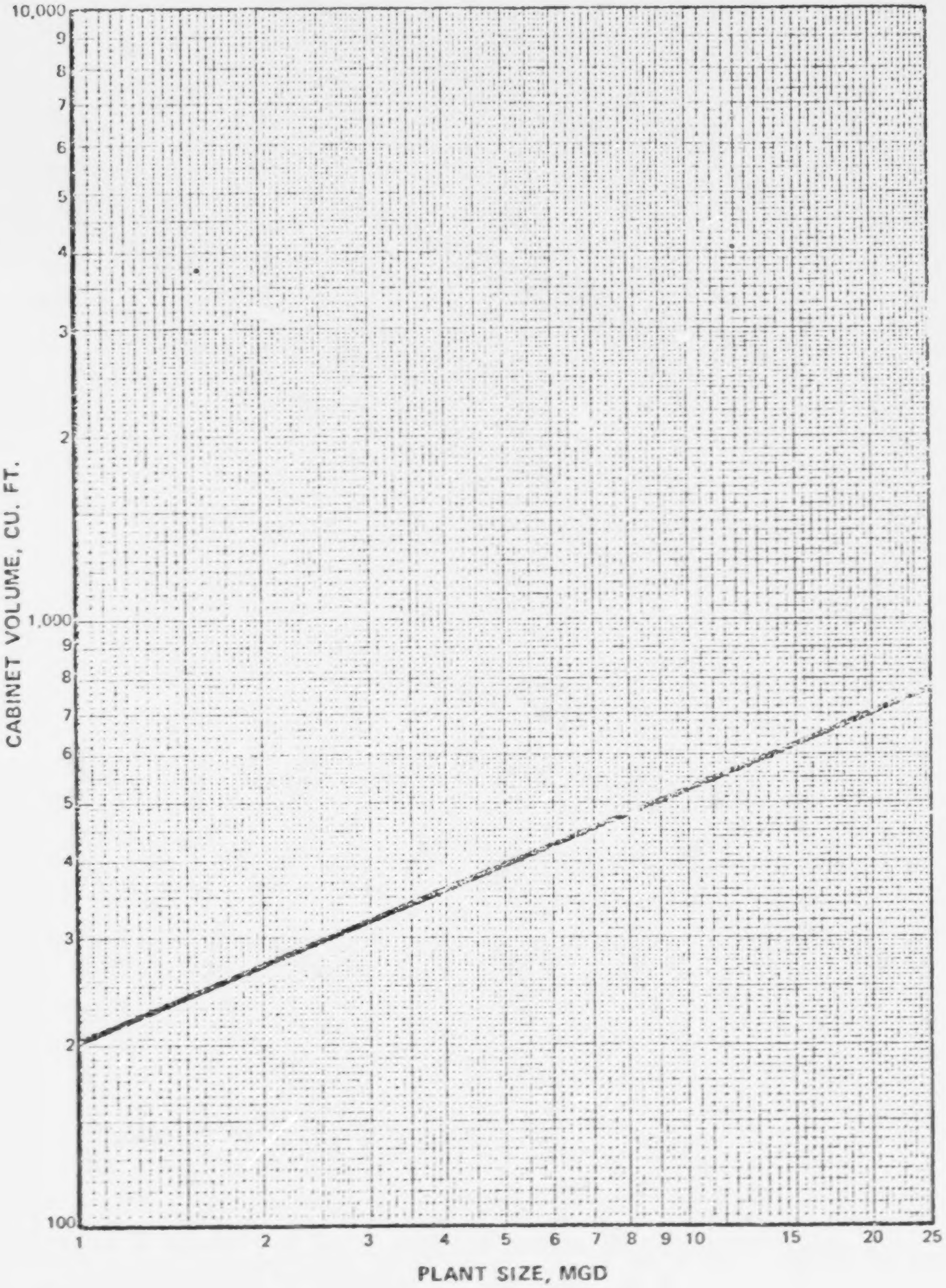
ESTIMATED LAB FLOOR SPACE



NOTE:

MINIMUM PERCENT OF FLOOR SPACE, REQUIRED FOR BENCH AREA, FOR PLANTS LESS THAN 1 MGD IS 40 PERCENT.

ESTIMATED BENCH AREA



NOTE:

MINIMUM CABINET VOLUME REQUIRED FOR PLANTS LESS THAN 1 MGD IS 200 CU. FT.

ESTIMATED CABINET VOLUME

## REFERENCES – LABORATORY PRACTICES

Gilbert, W.G. Municipal Wastewater Treatment: The Relation of Operation and Maintenance Activities to Plant Efficiency. Presented at 48th Annual Conference, Water Pollution Control Federation, Miami Beach, October 1975.

West, A.W. Operational Control Procedures for the Activated Sludge Process. Part II, Control Tests. Environmental Protection Agency, National Field Investigations Center, Cincinnati. 1973.

Hayes, R.B., and C.S. Zickefoose. Operator's Pocket Guide to Activated Sludge, Part II, Process Control and Troubleshooting. Stevens, Thompson & Runyan, Inc., Portland, Oregon, 1975.

URS Research Company. Procedures for Evaluating Performance of Wastewater Treatment Plants. U.S. Environmental Protection Agency.

Estimating Laboratory Needs for Municipal Wastewater Treatment Facilities. Environmental Protection Agency, Office of Water Program Operations, Washington, D.C. 1973.

Handbook for Analytical Quality Control in Water and Wastewater Laboratories. Environmental Protection Agency, Analytical Quality Control Laboratory, Cincinnati, Ohio. 1972.

Manual for Methods of Chemical Analysis of Water and Wastes. Environmental Protection Agency, Methods Development and Quality Assurance Research Laboratory, Cincinnati, Ohio. 1974.

Standard Methods for the Examination of Water and Wastewater. American Public Health Association, Fourteenth Edition.

## STUDENT NOTEBOOK MATERIALS

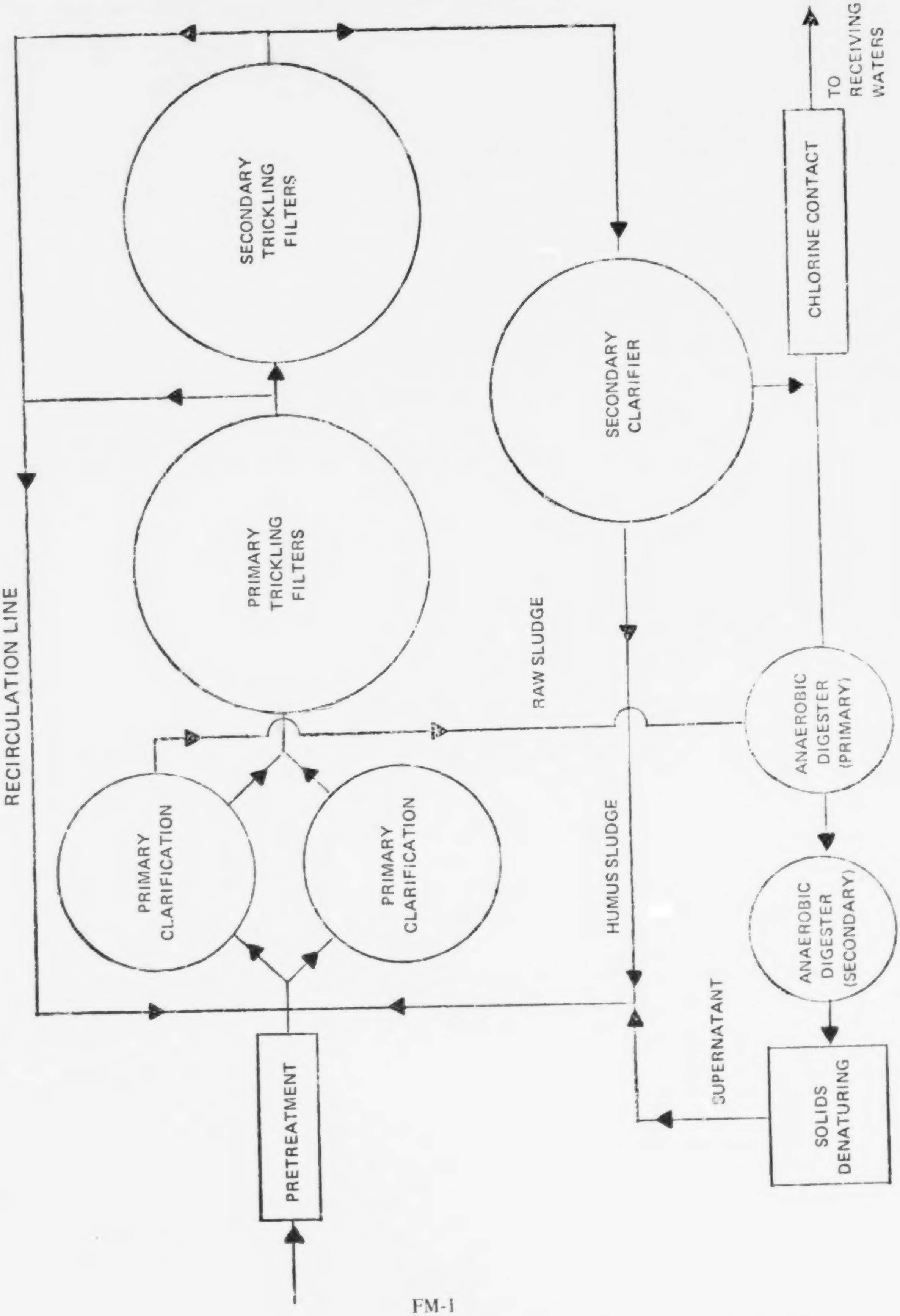
The following materials are included in the section of the Student Notebook on Flow Measurement. The Notebook is distributed to students at the start of the course, and is available to them as a reference material throughout the course.

The following materials in the Student Notebook are an integral part of the lesson plan, and *must* be used by the instructor at the appropriate point in the lesson:

### Index of Notebook Materials

| PAGES | MATERIAL | USE IN LESSON |
|---|---|---|
| FM – 1 | Trickling Filter Flow Diagram | Subdivision 1, Section III, Used as basis for student problem |
| FM – 2, 3 | Answer Sheets, Problems on Measuring Flow Volumes | Used by student groups to complete student problem solving exercises, Subdivision 1, Section III |
| FM – 4, 5 | Flow Measurement Troubleshooting Guide | Subdivision 2, Section III, Brief presentation of outline by instructor |
| FM – 6 | Flow Equations and Discharge Formulae | Subdivision 2, Section IV, Referred by instructor |
| FM – 7 | References | |

DESIGN FLOW: 10 MGD


RECIRCULATION LINE
PRETREATMENT
PRIMARY CLARIFICATION
PRIMARY CLARIFICATION
PRIMARY TRICKLING FILTERS
SECONDARY TRICKLING FILTERS
SECONDARY CLARIFIER
RAW SLUDGE
HUMUS SLUDGE
SUPERNATANT
ANAEROBIC DIGESTER (PRIMARY)
ANAEROBIC DIGESTER (SECONDARY)
SOLIDS DENATURING
CHLORINE CONTACT
TO RECEIVING WATERS

TRICKLING FILTER FLOW DIAGRAM

GROUP ______________________________ **ANSWER SHEET – Page 1**

## MEASURING FLOW VOLUMES – IMPACT ON PLANT OPERATIONS

1. Using the Trickling Filter Flow Diagram, identify the following major plant flows – by numbering key points on the flow diagram according to the type of flow, as follows:

   1. Influent flows
   2a. Internal flows – parallel distribution
   2b. Internal flows – series distribution
   3. Side streams (sludge, supernatant, etc)
   4. Chemical feeds – actual or possible
   5. Effluent

2. For each of the following processes, determine whether plant performance would be affected by the operator's inability to accurately measure flow volumes identified in question 1.

| **Process** | **Yes or No Performance Affected** | **Possible Indicators of Poor Performance** |
|---|---|---|
| a. Pretreatment | | |
| b. Primary Clarification | | |
| c. Trickling Filter | | |

GROUP ______________________________ **ANSWER SHEET – Page 2**

**Measuring Flow Volumes – Impact on Plant Operations – Continued**

| Process | Yes or No Performance Affected | Possible Indicators of Poor Performance |
|---|---|---|
| d. Secondary Clarifier | | |
| e. Digesters | | |
| f. Chlorination | | |
| g. Effluent Quality | | |

3. For each flow identified in Question 1, identify a flow measurement device that would normally be used

## FLOW MEASUREMENT TROUBLESHOOTING GUIDE

Note: This is presented as a systematic guide to students for troubleshooting flow measurement problems at treatment plants.

I. Analyze Plant Flow Measurement Capability

  A. Review plans and flow diagrams

    1. Define plant processes, operations, and sub-systems
    2. Locate sources and discharge points of all streams and side streams
    3. Study plant flexibility with respect to possible mode change
    4. Locate measuring devices and evaluate their adequacy with respect to:
      a. type of device used
      b. location
      c. size
      d. recording and totalling capability
      e. overall installation

  B. Tour facility

    1. Observe physical layout and location of measuring devices, valves, pumps and tanks
    2. Discuss plant performance with operator, plant personnel
    3. Seek the opinions of plant personnel
    4. Learn color coding, labeling and unit designations
    5. Examine measuring devices, their installation and condition

  C. Examine flow charts

    1. Evaluate trends
    2. Check for storm response
    3. Identify unusual deviations

  D. Study manufacturer's recommendations for user maintenance

    1. Review maintenance records

  E. Examine instrumentation

    1. Check for evidence of operator tampering

  F. Inspect weirs and flumes

    1. Measure appropriate heads
    2. Check instrument readings
    3. Check for obstructions, turbulence and condition of device
    4. Disturb floats, check for response on flow charts
    5. Observe surge action

II. Formulate Alternatives

A. Possible causes to plant problems

1. Poor control over specific treatment processes
2. Organic overloading
3. Poor management and administration

•

•

n. Difficulties or inaccuracies in measuring flows

B. Prioritize alternatives and corrective actions

C. Confirm opinion if possible

D. Get outside help if necessary

E. There may not be one single "right" answer

III. Take appropriate corrective actions, observe and test. With regard to flow measurement problems, this may mean

A. Major Corrective Action

1. Install metering equipment at points where flow data is necessary
2. Repair existing flow measurement systems
3. Calibrate existing flow measurement systems
4. Modify or replace systems for transmitting, recording or totalling flow data
5. Correct faulty installations, and conditions which cause flow measurement devices to operate improperly
6. Cleaning and preventive maintenance
7. Develop accurate charts
8. Install counters and timers on pumps

B. Expedient Actions on a Temporary Basis — Until Permanent Improvement Can be Made

1. Improve or "fix-up" present systems
2. Install temporary recorders
3. Calibrate existing devices
4. Install devices to facilitate quick measurements in the future
5. Install temporary measuring systems
6. Calculate flows from pipe or channel measurements
7. Compute flows using pump curves

C. Flow balancing and equalization within the plant

1. Equalize flows to parallel plant units
2. Increase or decrease flows where necessary for process control
3. Balance solid loadings by using centrifuge
4. Modify chemical feed rates

## DISCHARGE FORMULAE*

1. Basic Flow Formula $Q = AV$
2. Mannings Formula $V = \frac{1.486}{n} R^{2/3} S^{1/2}$ (Flow in pipes)
3. 90° V-notch weir $Q = 2.52\,H^{2.47}$ cfs
4. 60° V-notch weir $Q = 1.43\,H^{5/2}$ cfs
5. Proportional weir $Q = [illegible]\,bH$ cfs
6. Rectangular weir $Q = 3.33\,LH^{3/2}$ cfs
7. Cipolletti weir $Q = 3.367\,LH^{3/2}$ [illegible]
8. Parshall Flume $Q = 4WH_a^{[illegible]}$ [illegible]
9. Venturi meter $Q = C_1 A_2$ [illegible]
10. Orifice $Q = C_d A\sqrt{2gh}$
11. Parabolic flume, 12. Magnetic meter: Calibrated by manufacturer
13. California Pipe Method [illegible]
14. Board of Water Engineers Method
15. Volume Displacement Method

Q = flow
A = cross sectional area
V = velocity
n = roughness coef.
R = hydraulic radius
S = slope
H, h = head
m = width at the point
where H = [illegible]

W = throat width
[illegible]

*Courtesy of the Texas Water Quality Board, Austin, Texas

## REFERENCES – FLOW MEASUREMENT

URS Research Company. Procedural Manual for Evaluating Performance of Wastewater Treatment Plants. Environmental Protection Agency.

The Texas Water Utilities Association. Manual of Wastewater Operations. 1971.

U.S. Department of Interior, Bureau of Reclamation. Water Measurement Manual, 2nd Edition. Available from Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 – Order No. I 27.19/2: W29/2. 1971.

Leopold Stevens, Inc. Hydrographic Data Book, 8th Edition. P.O. Box 25347, Portland, Oregon 97225.

Manning Environmental Corporation. Flow Tables for Circular Pipes. 112 Dakota Avenue, Santa Cruz, California 95060.

King, W.K., and E.F. Brater. Handbook of Hydraulics, 5th Edition. McGraw-Hill, New York 1963.

Davis, D.V., and D.E. Sorensen. Handbook of Applied Hydraulics, 3rd Edition. McGraw-Hill, New York, 1969.

Bauer, S.W., and W.H. Graf. Free Overfall as Flow Measuring Device. In Proceedings, American Society of Civil Engineers, Journal, Irrigation Drainage Division, 97 IR, 7987, 1971.

National Bureau of Standards, U.S. Department of Commerce. A Guide to Methods and Standards for the Measurement of Water Flow, 1975.

Office of Research and Monitoring, U.S. EPA. Flow Augmenting Effects of Additives on Open Channel Flows. Environmental Protection Technology Series, EPA-R2-83-238, Washington, D.C. 20460, 1973.

## LESSON: CHEMICAL ADDITIONS

### Index of Notebook Materials

| Pages | Material | Use in Lesson |
|---|---|---|
| CA – 1 thru 3* | Tables on the effect of Chemical Additions | Reference by Instructor<br>Subdivision 1, Section II |
| CA – 4, 5 | Example on determining Chemical Dosage, and Typical Jar Test Results | Class is to review the example, and the jar test results. Instructor is to discuss jar test results with class<br>Subdivision 1, Section III |
| CA – 6* | Coagulation of Raw Sewage with Alum- graphs | Reference by instructor<br>Subdivision 1, Section III-D |
| CA – 7 thru 14* | Diagrams of Various Chemical Feed Systems | Reference and brief discussion of each feed system by instructor.<br>Subdivision 1, Section IV-D |
| CA – 15 | Table – Types of Chemical Feeders | Reference by instructor<br>Subdivision 1, Section IV-D |
| CA – 16 | Example: Innovative Plant Personnel and Alum Make Successful Phosphorus Removal Team at Grandville, Michigan | Reference by instructor. To be read by students following lesson.<br>Subdivision 2, Section V. |
| CA – 19 & 20 | References | |

* Denotes pages reproduced from EPA Manual "Upgrading Existing Wastewater Treatment Plants."

Reproduced from EPA Process Design Manual for
Upgrading Existing Wastewater Treatment Plants

## EFFECT OF CHEMICAL TREATMENT ON PRIMARY CLARIFIER PERFORMANCE

| Type and Amount of Chemical Added | Performance Preceding Chemical Treatment | | | | Weight Ratio of WAS/PS[1] | Performance After Chemical Treatment | | | | Weight Ratio of WAS/PS[1] | Reference |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | SS Removed | | BOD Removed | | | SS Removed | | BOD Removed | | | |
| | mg/l | percent | mg/l | percent | | mg/l | percent | mg/l | percent | | |
| Purifloc – A21 (0.95 mg/l) | 13 | 12 | 28 | 26 | 0.61 | 75 | 65 | 46 | 48 | 0.31 | 21 |
| DOW – SA 1193 (0.2 mg/l) | 13 | 12 | 28 | 26 | 0.61 | 72 | 55 | 36 | 37 | 0.41 | 21 |
| Purifloc – A21 (1 mg/l) | 157 | 43 | 82 | 23 | – | 281 | 76 | 127 | 33 | – | 21 |
| Purifloc – A21 (0.75 mg/l) | 26 | 18 | – | – | – | 69 | 52 | – | – | – | 21 |
| Purifloc – A21 (0.89 mg/l) | 113 | 43 | 50 | 22 | – | 159 | 60 | 87 | 37 | – | 21 |
| DOW – SA1193 (0.25 mg/l) | 120 | 47 | – | – | 0.8 | 151 | 61 | – | – | 0.46 | 21 |
| Purifloc – A21 (1 mg/l) | 107 | 47 | 135 | 37 | – | 169 | 62 | 154 | 46 | – | 21 |
| $FeCl_2$ + NaOH + Purifloc - A23 (0.3 mg/l) | 230 | 82 | 111 | 31 | – | 379 | 79 | 74 | 39 | – | 22,23 |
| $FeCl_2$ + NaOH + Purifloc – A23 (0.3 mg/l) | 104 | 49.7 | 83 | 43.8 | – | 173 | 76.8 | 105 | 57.8 | – | 22,23 |
| Purifloc – A21 (1 mg/l) | – | – | – | – | 0.79 | – | – | – | – | 0.28 | 24 |
| Purifloc – A23 (0.25 mg/l) | 52 | 31 | 47 | 31 | 1.44 | 80 | 51 | 58 | 46.4 | 0.67 | 25 |
| $FeCl_3$ + Purifloc – A23 | 93 | 33 | 53 | 34 | – | 196 | 74 | 102 | 61 | – | 26 |
| $FeCl_3$ + Purifloc – A23 | 93 | 33 | 53 | 34 | – | 213 | 63 | 97 | 53 | – | 26 |
| Purifloc – A21 (0.74 mg/l) | – | 50 | – | 36 | – | – | 63 | – | 45 | – | 27 |
| Purifloc – A21M (1.14 mg/l) | – | 43 | – | – | – | – | 63 | – | – | – | 27 |
| $FeCl_3$ (20 mg/l) + Purifloc – A23 (0.3 mg/l) | 1 | 1.3 | – | – | – | 38 | 24.4 | – | – | – | 28 |
| $FeCl_3$(35 mg/l $Fe^{3+}$) + Purifloc – A23 (0.5 mg/l) | – | – | – | – | – | 323 | 80 | 249 | 61 | – | 29 |
| $FeCl_3$ (15–18 mg/l $Fe^{3+}$) + Purifloc – A23 (0.5 mg/l) | – | 35.5 | – | 19.1 | – | – | 63.6 | – | 54.4 | – | 30 |
| $FeCl_3$ (10 mg/l $Fe^{3+}$) + Purifloc – A23 (0.5 mg/l) | – | – | – | – | – | 177 | 74.5 | – | – | – | 31 |
| $FeCl_3$ (20-25 mg/l $Fe^{3+}$) + Purifloc – A23 (0.4 mg/l) | – | – | – | – | – | 41 | 74.0 | 115 | 57.4 | – | 32 |
| $FeCl_3$(22 mg/l $Fe^{3+}$) + Purifloc – A23 (0.5 mg/l) | – | – | – | – | – | 61.7 | 84 | 226 | 38 | – | 33 |
| Alum (15–20 mg/l $Al^{3+}$) + Purifloc – A23 (0.5 mg/l) | – | – | – | – | – | 134.8 | 70 | 423.9 | 32 | – | 33 |
| Alum (90 mg/l) + Polyelectrolyte (0.4 mg/l) | – | – | – | – | – | 157 | 84 | 66 | 61.1 | – | 34 |
| Alum (110 mg/l) + Polyelectrolyte (0.35 mg/l) | – | – | – | – | – | 204 | 74 | 126 | 71 | – | 35 |

[1] WAS – Waste activated sludge
PS – Primary sludge

Reproduced from EPA Process Design Manual for
Upgrading Existing Wastewater Treatment Plants

## POLYELECTROLYTE ADDITION TO PRIMARY CLARIFIERS

| Treatment Process | Coagulant | Dose | Primary Clarifier | | | | Total Plant | | | | Reference |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Percent Removal Before Polyelectrolyte Addition | | Percent Removal After Polyelectrolyte Addition | | Percent Removal Before Polyelectrolyte Addition | | Percent Removal After Polyelectrolyte Addition | | |
| | | mg/l | BOD | SS | BOD | SS | BOD | SS | BOD | SS | |
| Activated Sludge | Purifloc A-21 | 1 | 26 | – | 48 | – | 83 | – | 90 | – | 37 |
| Trickling Filter | Purifloc A-21 | 1 | 23 | 43 | 33 | 76 | 79 | 72 | 85 | 84 | 37 |
| Activated Sludge[1] | Purifloc A-23 | 0.21 | 31 | 31 | 46 | 51 | 79 | 85 | 83 | 89 | 38 |

## LIME ADDITION TO PRIMARY CLARIFIERS

| Location | Lime Added | Percent Removal in Primary Before Lime Addition | | Percent Removal in Primary After Lime Addition | | Remarks | Reference |
|---|---|---|---|---|---|---|---|
| | mg/l CaO | BOD | SS | BOD | SS | | |
| Duluth, Minnesota | 75 | 50 | 70 | 60 | 75 | – | 18 |
| | 125 | 55 | 70 | 75 | 90 | – | |
| Rochester, New York | 100 | – | – | 50 | 80-90 | Jar tests | 18 |
| Lebanon, Ohio | 145 | – | – | 66 | 74 | Pilot plant | 40 |
| Richmond Hill, Ontario | 175 | 21 | 37 | 71 | 77 | Full-scale plant | 41 |
| Central Contra Costa, Calif. | 378 | 46 | 71 | 74 | 79 | Full-scale test | 42 |
| | 303 | 37 | 71 | 69 | 76 | Full-scale test | |

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[1] Case history presented in Chapter 13.

Reproduced from EPA Process Design Manual for
Upgrading Existing Wastewater Treatment Plants

## EFFECT OF CHEMICAL TREATMENT ON SECONDARY CLARIFIER PERFORMANCE

| Location | Type of Plant | Location of Chemical Addition | Chemical and Dosage | Effluent BOD$_5$ (or COD) Before Chemical Addition mg/l | Effluent SS Before Chemical Addition mg/l | Effluent BOD$_5$ (or COD) After Chemical Addition mg/l | Effluent SS After Chemical Addition mg/l | Total Phos. Removal percent | Reference |
|---|---|---|---|---|---|---|---|---|---|
| Richardson, Texas | Trickling filter std. rate | Before final settling | Al/P Mole Dosage 1.6/1 | 20 | 15 | <5 | <7 | 95 | 44 |
| Chapel Hill, North Carolina | Trickling filter high rate | Before final settling | Al/P Mole Dosage 1.6/1 | 44 | 64 | 15 | 34 | 82 | 45 |
| Pennsylvania State | Conventional activated sludge | Aerator effluent | Al/P wt Ratio 3/1 | 13 | 26 | 9 | 22 | 86 | 46 |
| Cincinnati, Ohio | Activated sludge (100 gpd pilot) | Aerator | 10 mg/l Al$^{3+}$ | (89%)[1] | (95%)[1] | (92%)[1] | (96%)[1] | 94 | 47 |
| Lebanon, Ohio | Activated sludge (0.11 mgd pilot) | Final clarifier | Add lime to raise pH=9.4-10.9 | — | 43.5 | — | 16.5 | | 48 |
| Minneapolis, Minnesota | Trickling filter low rate | Before final settling | 720 mg/l Ca(OH)$_2$ | 83 | — | 27 | | 86 | 49 |
| Madison, Wisconsin | — | Before final settling | 200 mg/l Alum | 8–29 | — | 1.8–2.9 | — | 98.7 | 50 |
| University Park, Pennsylvania | Trickling filter | Before final settling | 160 mg/l Alum | 18 | 31 | 6 | 19 | 96.4 | 51 |
| | | | 46 mg/l Na$_2$Al$_2$O$_4$ | 61 | 95 | 23 | 8 | 93.4 | |
| Bloomington, Illinois | Activated sludge | Aerator | 33.9 mg/l Fe$^{3+}$ +0.7 mg/l Purifloc – A23 | 8.8 | 12.7 | 5.0 | 8.6 | | 50 |
| | Trickling filter | Before final settling | 25-30 mg/l Fe$^{3+}$ +0.5 mg/l Purifloc – A23 | 13.0 | 49.6 | 3.3 | 16.0 | | 50 |
| Blue Plains,[2] Washington, D.C. | Modified Activated sludge | Before final settling | 26 mg/l Alum | 47 | 48 | 40 | 43 | | |
| | | | 50 mg/l Alum | 38 | 39 | 27 | 36 | | |
| | | | 60 mg/l Alum | 68 | 53 | 25 | 36 | | 52 |
| | | | 80 mg/l Alum | 46 | 41 | 41 | 31 | | |
| | | | 89 mg/l Alum | 50 | 57 | 30 | 31 | | |
| Sandusky, Ohio | Conventional activated sludge | Aerator | 50 mg/l Alum | 9 | 24 | 2 | 15 | 80 | 35 |
| Michigan City, Indiana | Conventional activated sludge | Aerator | 60 mg/l Alum | 13 | 19 | 9 | 7 | 92.2 | 35 |
| Guelph, Ontario | Conventional activated sludge | Aerator | 100 mg/l Alum | 26 | 38 | 14 | 22 | 87 | 35 |
| Palmetto, Florida | Trickling filter | Before final settling | 45 mg/l Alum | — | 30-40 | — | 10 | | 35 |

[1] Percent removal

[2] Data are monthly average

## EXAMPLE 1 – DETERMINING CHEMICAL DOSAGE: JAR TEST

For any given treatment system there are a large number of coagulants and combinations of coagulants and coagulant aids (polymers) that can be used to obtain the required effluent quality. The difficult task is to identify those combinations that are best in terms of economics and other considerations. Other considerations being: sludge volume and dewatering characteristics, chemical delivery times and storage requirements, hazards associated with some materials, and so forth.

Chemical dosages required can be estimated in the laboratory using standard jar testing apparatus. The jar test procedure used should be designed to simulate, as close as possible, the chemical addition and mixing conditions found in the full scale process. The test will generally follow the scheme outlined below:

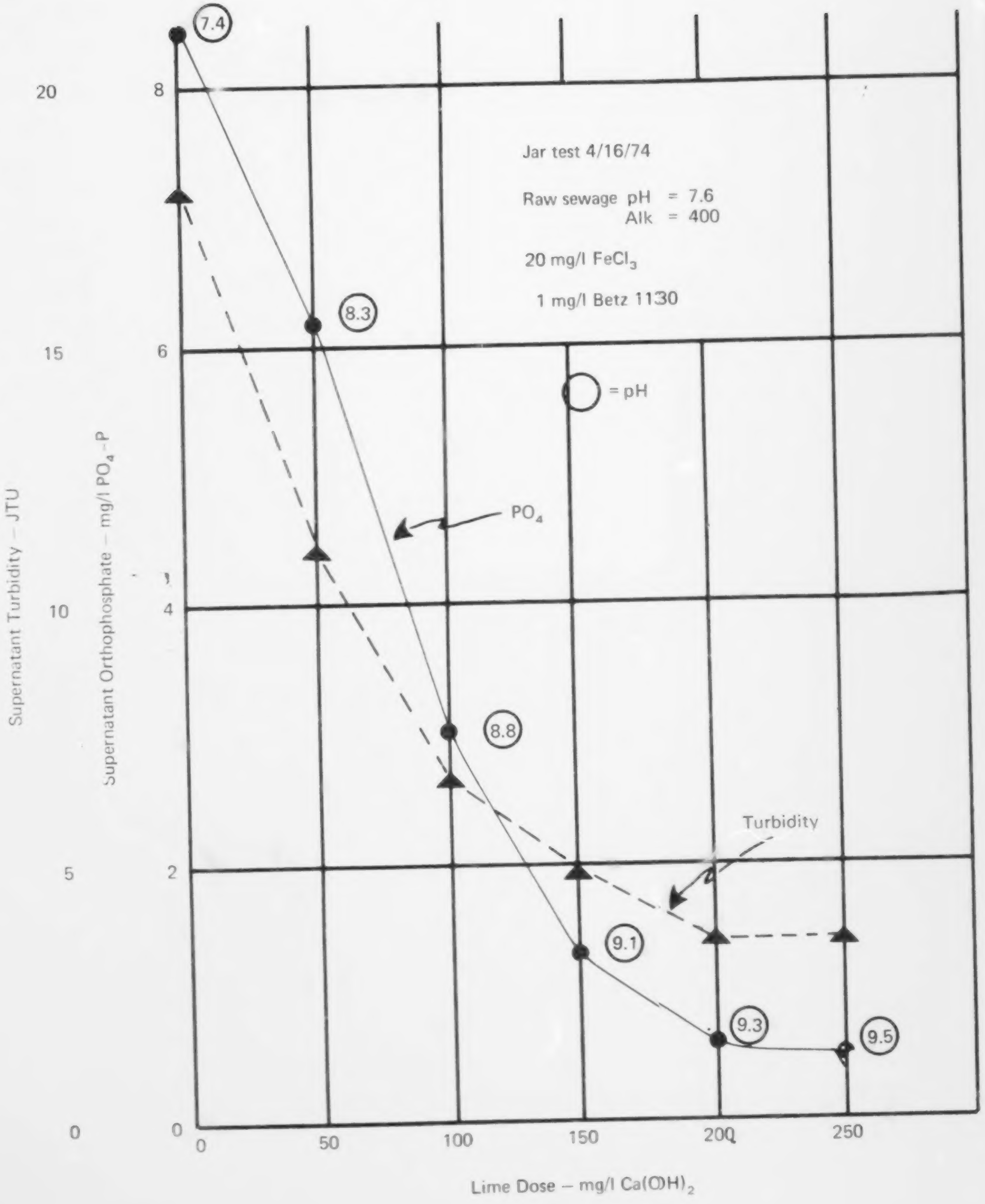
1. Coagulant addition and rapid mix for 15-60 sec. (100 rpm)
2. Slow mix for 5-30 min. (20-30 rpm)
3. Add polymer and continue slow mix 5-10 min.
4. Settle 10-60 min.
5. Sample for analyses

The results of a typical jar test are presented in Figure 1, page CA-5. The test was conducted to observe the effect of lime dose (pH) on phosphorus and turbidity removals when used with ferric chloride and polymer. The test procedure was:

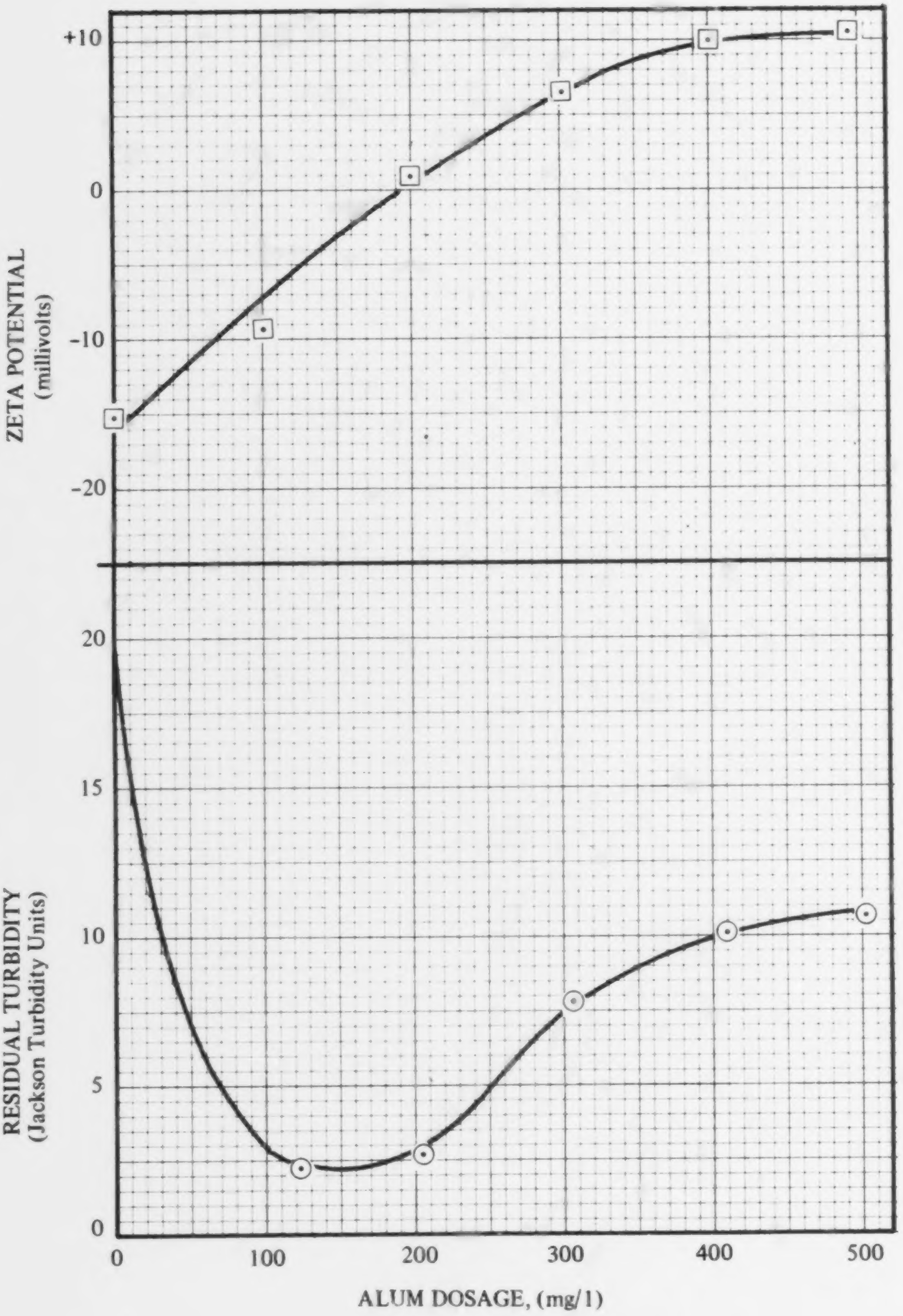
1. Fill 6 jars with 1 liter raw sewage each
2. Add lime and rapid mix for 5 minutes at 100 rpm
3. Add ferric chloride and rapid mix for 1 minute at 100 rpm
4. Mix at 50 rpm for 1 minute
5. Add polymer and mix for 1 minute at 50 rpm
6. Slow mix for 15 minutes at 25 rpm
7. Settle for 25 minutes
8. Sample Supernatant

The raw sewage characteristics were:

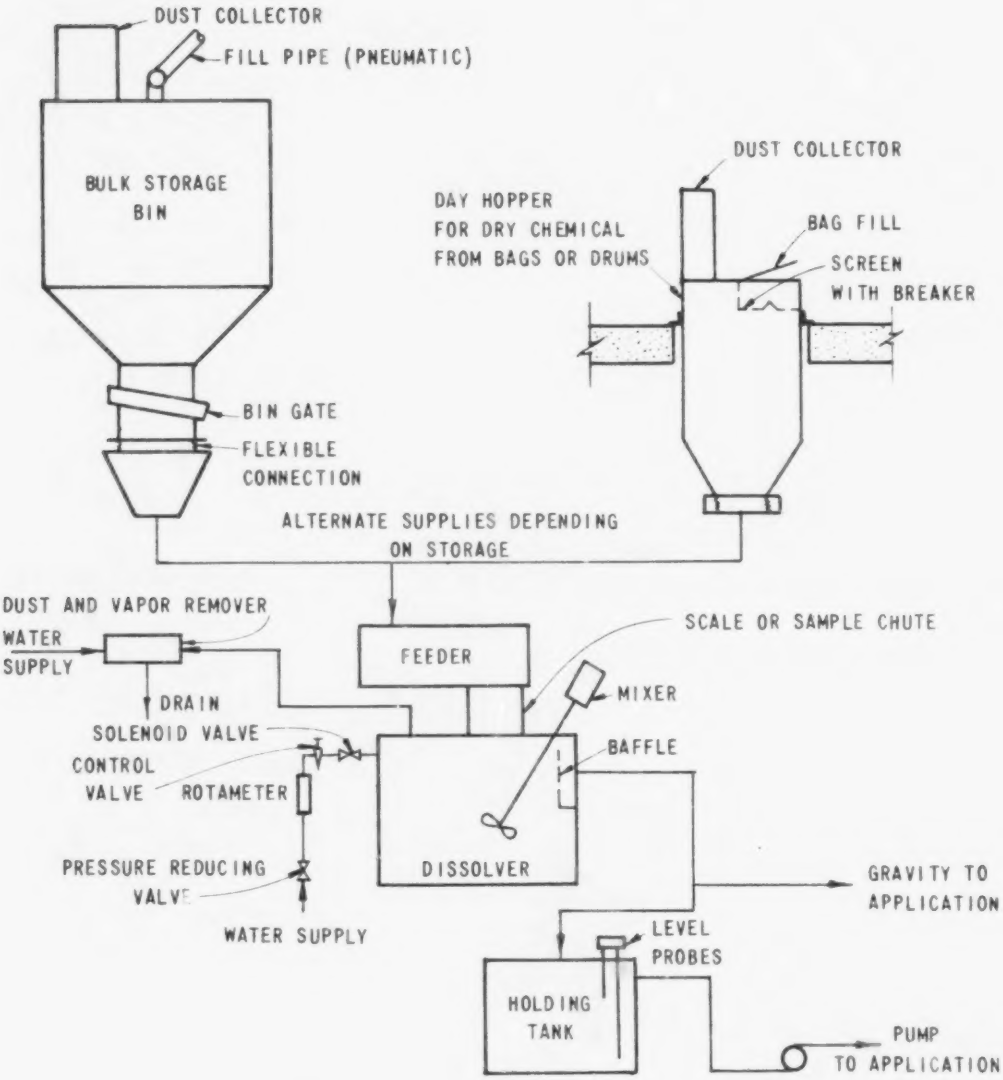
pH = 7.6
Alkalinity = 400 mg/l as $CaCO_3$
$PO_4$-P = 10.8 mg/l



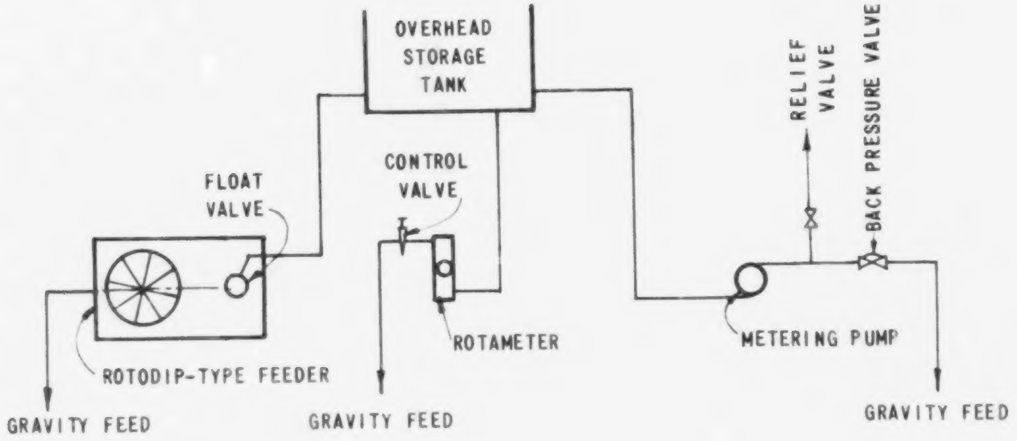
TYPICAL JAR TEST RESULTS



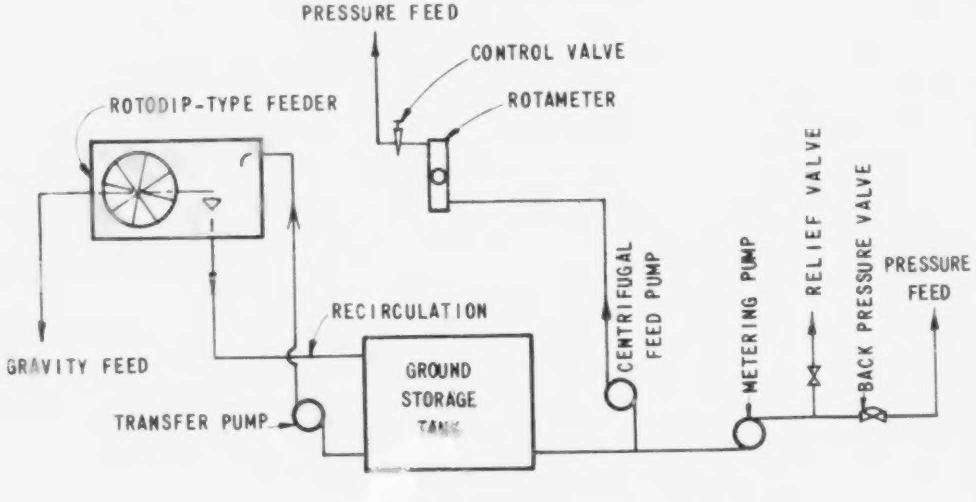
COAGULATION OF RAW SEWAGE WITH ALUM


DUST COLLECTOR
FILL PIPE (PNEUMATIC)
BULK STORAGE BIN
BIN GATE
FLEXIBLE CONNECTION
DUST COLLECTOR
DAY HOPPER FOR DRY CHEMICAL FROM BAGS OR DRUMS
BAG FILL
SCREEN WITH BREAKER
ALTERNATE SUPPLIES DEPENDING ON STORAGE
DUST AND VAPOR REMOVER
WATER SUPPLY
DRAIN
FEEDER
SCALE OR SAMPLE CHUTE
MIXER
SOLENOID VALVE
CONTROL VALVE
ROTAMETER
BAFFLE
PRESSURE REDUCING VALVE
WATER SUPPLY
DISSOLVER
GRAVITY TO APPLICATION
LEVEL PROBES
HOLDING TANK
PUMP TO APPLICATION

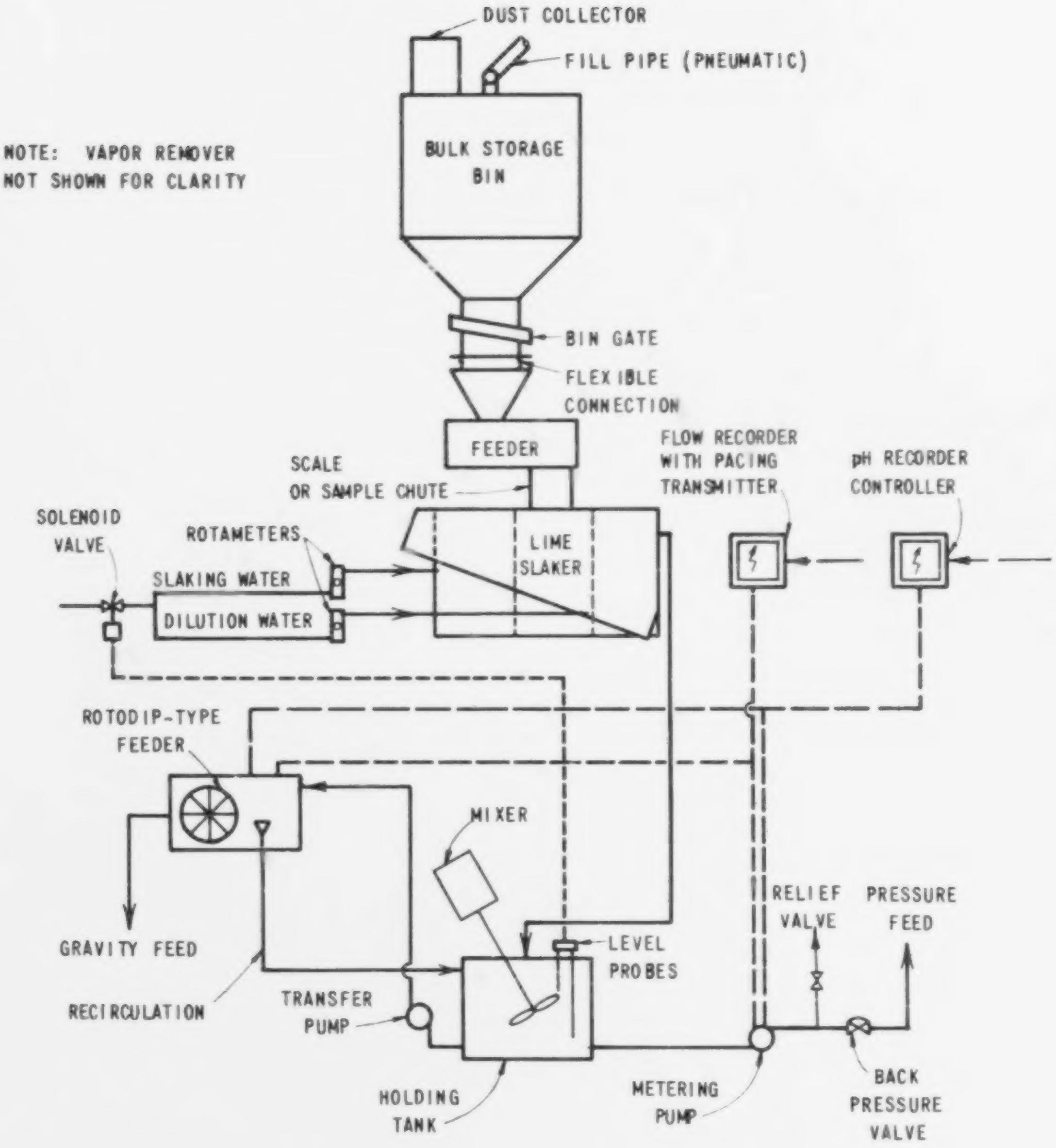
TYPICAL DRY FEED SYSTEM


OVERHEAD STORAGE TANK
RELIEF VALVE
BACK PRESSURE VALVE
CONTROL VALVE
FLOAT VALVE
ROTAMETER
METERING PUMP
ROTODIP-TYPE FEEDER
GRAVITY FEED
GRAVITY FEED
GRAVITY FEED

ALTERNATIVE LIQUID FEED SYSTEMS
FOR OVERHEAD STORAGE

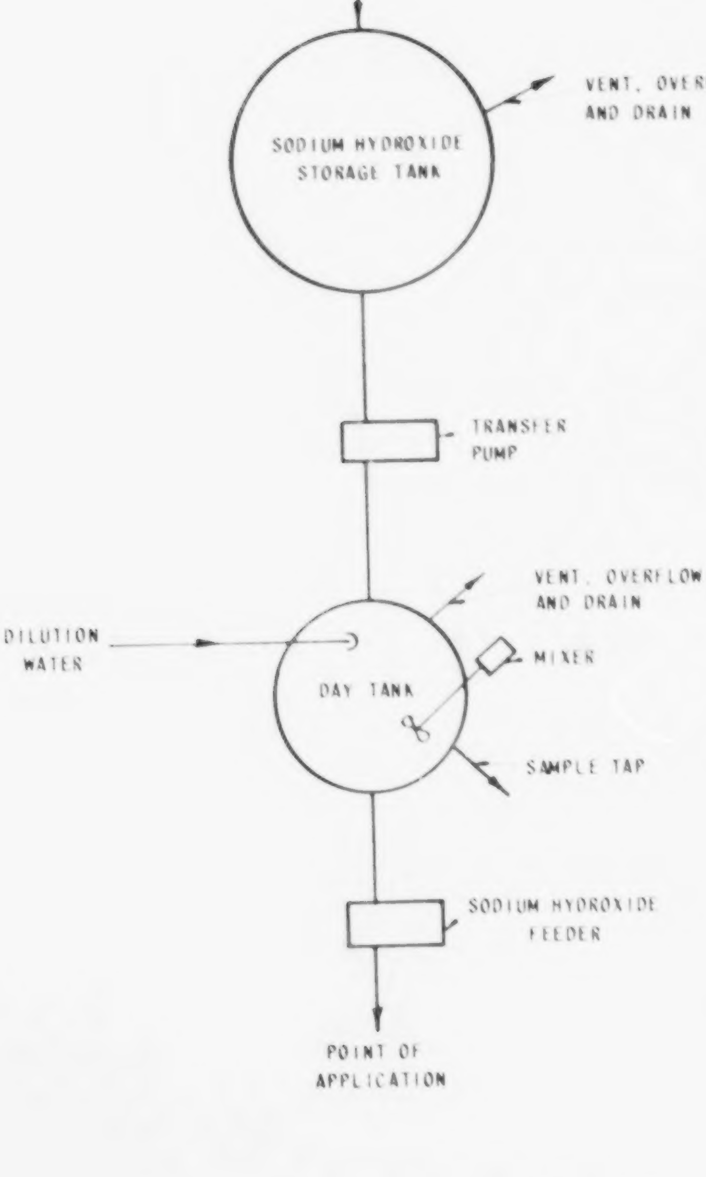

PRESSURE FEED
CONTROL VALVE
ROTAMETER
ROTODIP-TYPE FEEDER
RELIEF VALVE
BACK PRESSURE VALVE
PRESSURE FEED
CENTRIFUGAL FEED PUMP
METERING PUMP
RECIRCULATION
GRAVITY FEED
GROUND STORAGE TANK
TRANSFER PUMP

ALTERNATIVE LIQUID FEED SYSTEMS
FOR GROUND STORAGE

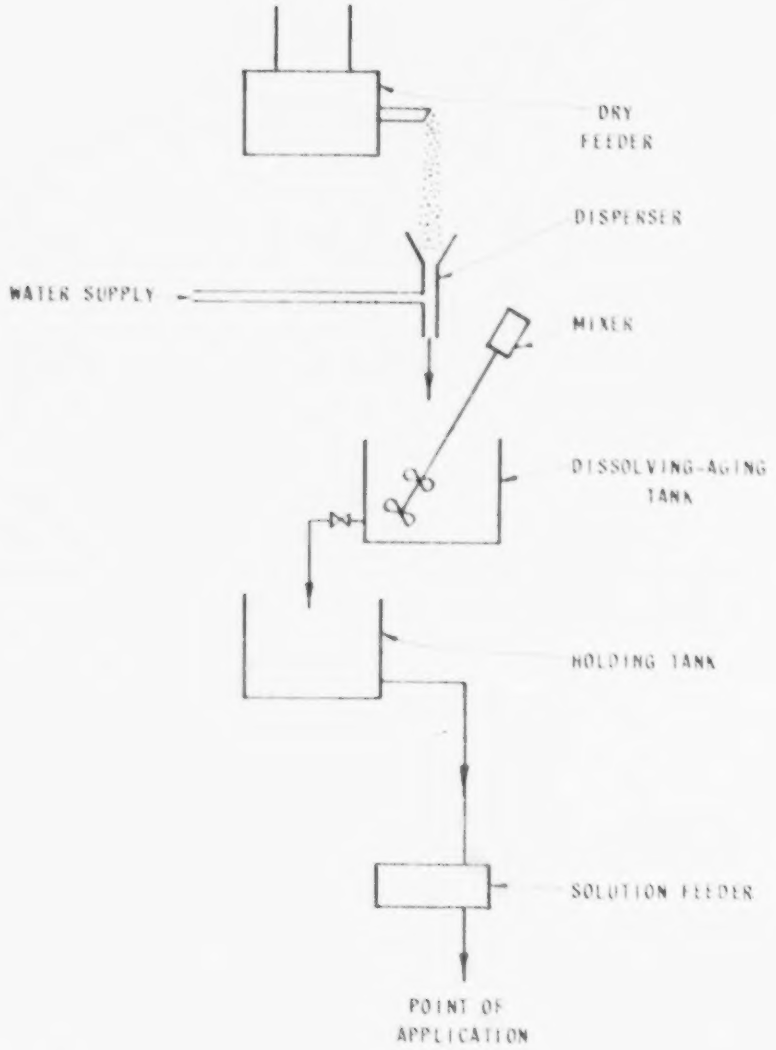

DUST COLLECTOR
FILL PIPE (PNEUMATIC)
BULK STORAGE BIN
BIN GATE
FLEXIBLE CONNECTION
FEEDER
SCALE OR SAMPLE CHUTE
FLOW RECORDER WITH PACING TRANSMITTER
pH RECORDER CONTROLLER
SOLENOID VALVE
ROTAMETERS
SLAKING WATER
DILUTION WATER
LIME SLAKER
ROTODIP-TYPE FEEDER
MIXER
GRAVITY FEED
LEVEL PROBES
RELIEF VALVE
PRESSURE FEED
RECIRCULATION
TRANSFER PUMP
HOLDING TANK
METERING PUMP
BACK PRESSURE VALVE

NOTE: VAPOR REMOVER NOT SHOWN FOR CLARITY

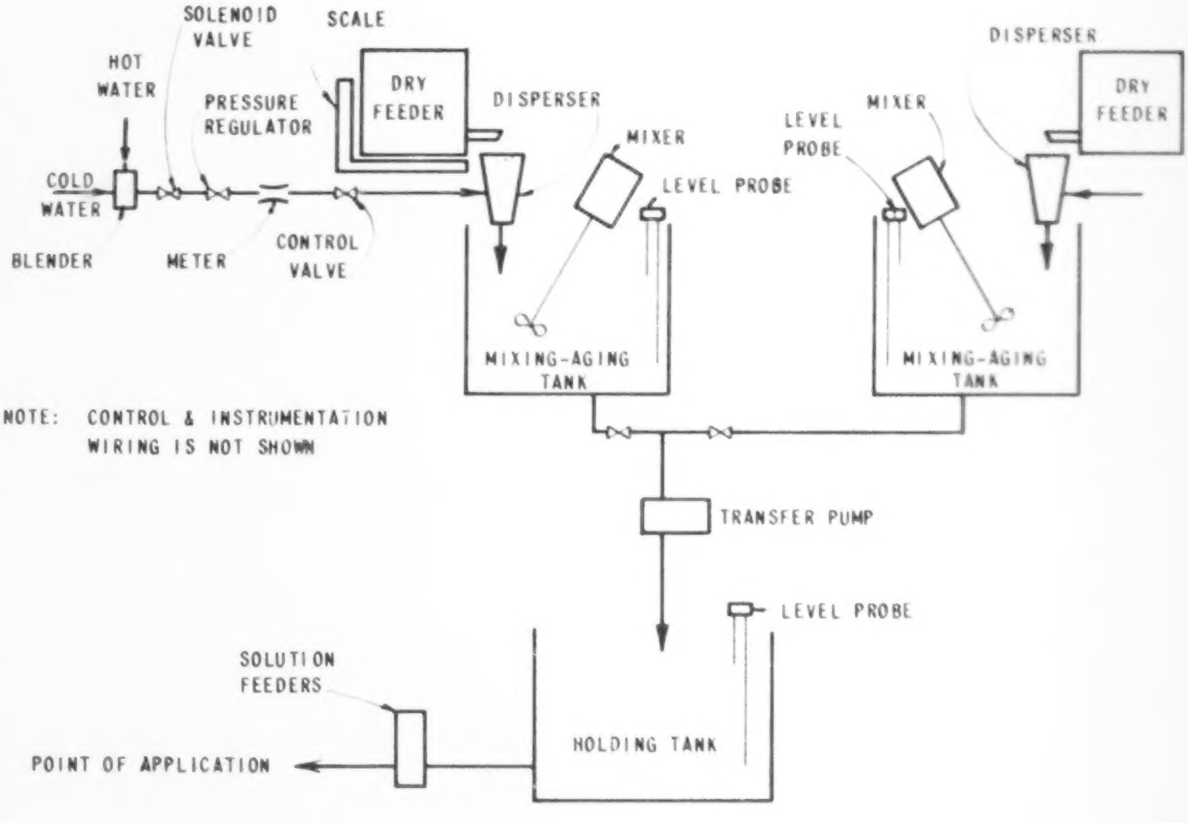
TYPICAL LIME FEED SYSTEM


TRUCK FILL LINE
VENT, OVERFLOW AND DRAIN
SODIUM HYDROXIDE STORAGE TANK
TRANSFER PUMP
VENT, OVERFLOW AND DRAIN
DILUTION WATER
MIXER
DAY TANK
SAMPLE TAP
SODIUM HYDROXIDE FEEDER
POINT OF APPLICATION

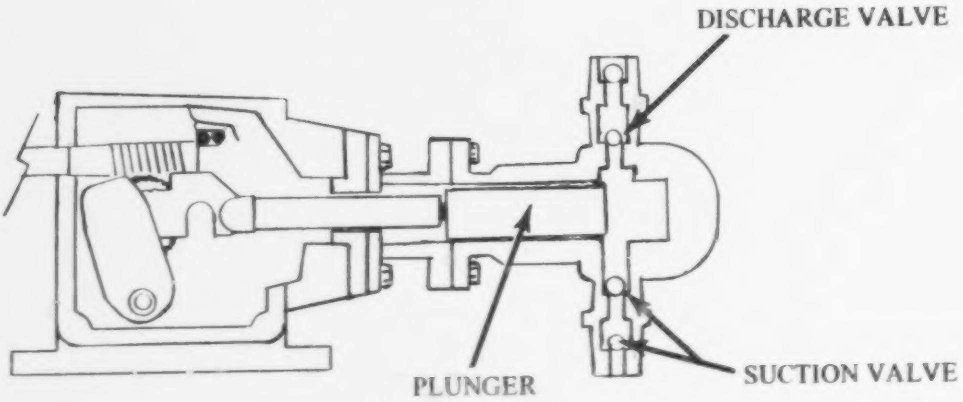
TYPICAL CAUSTIC SODA FEED SYSTEM


DRY FEEDER
DISPERSER
WATER SUPPLY
MIXER
DISSOLVING-AGING TANK
HOLDING TANK
SOLUTION FEEDER
POINT OF APPLICATION

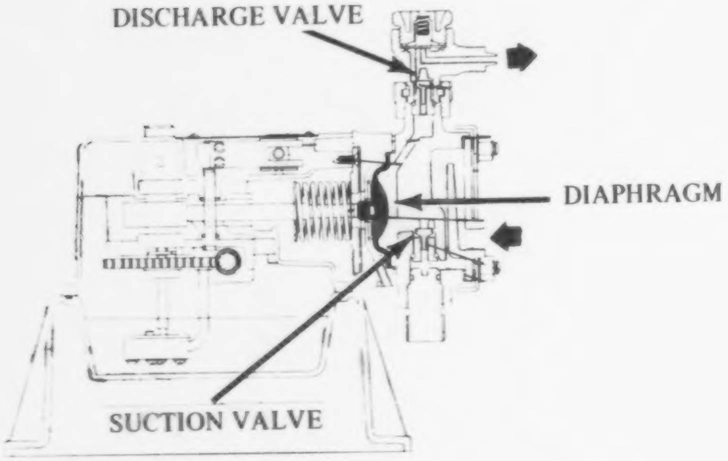
TYPICAL SCHEMATIC OF A DRY POLYMER FEED SYSTEM


SOLENOID VALVE
SCALE
HOT WATER
DRY FEEDER
PRESSURE REGULATOR
DISPERSER
MIXER
LEVEL PROBE
COLD WATER
BLENDER
METER
CONTROL VALVE
MIXING-AGING TANK
DISPERSER
DRY FEEDER
MIXER
LEVEL PROBE
MIXING-AGING TANK
NOTE: CONTROL & INSTRUMENTATION WIRING IS NOT SHOWN
TRANSFER PUMP
LEVEL PROBE
SOLUTION FEEDERS
HOLDING TANK
POINT OF APPLICATION

TYPICAL AUTOMATIC DRY POLYMER FEED SYSTEM


DISCHARGE VALVE
PLUNGER
SUCTION VALVE

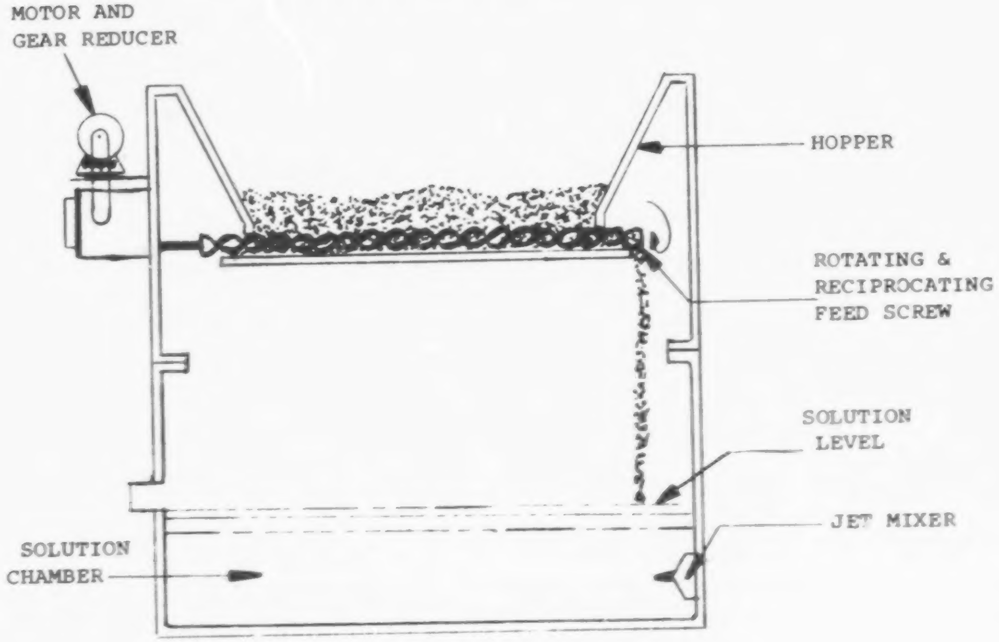
PLUNGER PUMP (Courtesy of Wallace & Tiernan)

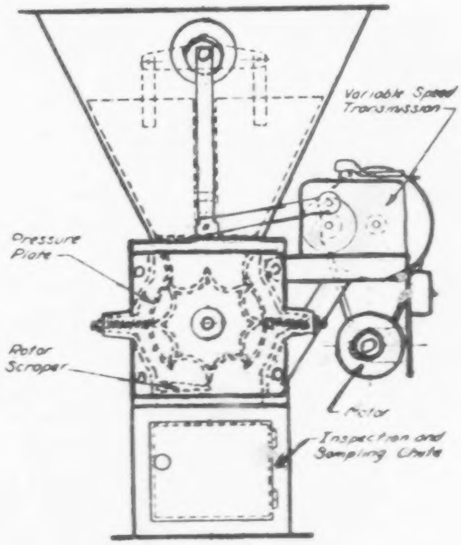

DISCHARGE VALVE
DIAPHRAGM
SUCTION VALVE

DIAPHRAGM PUMP (Courtesy of Wallace & Tiernan)

POSITIVE DISPLACEMENT PUMPS

SCREW FEEDER


MOTOR AND
GEAR REDUCER
HOPPER
ROTATING &
RECIPROCATING
FEED SCREW
SOLUTION
LEVEL
JET MIXER
SOLUTION
CHAMBER


Variable Speed
Transmission
Pressure
Plate
Rotor
Scraper
Motor
Inspection and
Sampling Chute

POSITIVE DISPLACEMENT SOLID
FEEDER—ROTARY (15)

# TYPES OF CHEMICAL FEEDERS

| Type of Feeder | Use | Limitations | | |
|---|---|---|---|---|
| | | General | Capacity cu ft/hr | Range |
| Dry feeder: | | | | |
| Volumetric: | | | | |
| Oscillating plate | Any material, granules or powder. | | 0.01 to 35 | 40 to 1 |
| Oscillating throat (universal) | Any material, any particle size. | | 0.02 to 100 | 40 to 1 |
| Rotating disc | Most materials including NaF, granules or powder. | Use disc unloader for arching. | 0.01 to 1.0 | 20 to 1 |
| Rotating cylinder (star) | Any material, granules or powder. | | 8 to 2,000<br>or<br>7.2 to 300 | 10 to 1<br>or<br>100 to 1 |
| Screw | Dry, free flowing material, powder or granular. | | 0.05 to 18 | 20 to 1 |
| Ribbon | Dry, free flowing material, powder, granular, or lumps. | | 0.002 to 0.16 | 10 to 1 |
| Belt | Dry, free flowing material up to 1½-inch size, powder or granular. | | 0.1 to 3,000 | 10 to 1<br>or<br>100 to 1 |
| Gravimetric: | | | | |
| Continuous - belt and scale | Dry, free flowing, granular material, or floodable material. | Use hopper agitator to maintain constant density. | 0.02 to 2 | 100 to 1 |
| Loss in weight | Most materials, powder, granular or lumps. | | 0.02 to 80 | 100 to 1 |
| Solution feeder: | | | | |
| Nonpositive displacement: | | | | |
| Decanter (lowering pipe) | Most solutions or light slurries | | 0.01 to 10 | 100 to 1 |
| Orifice | Most solutions | No slurries | 0.16 to 5 | 10 to 1 |
| Rotameter (calibrated valve) | Clear solutions | No slurries | 0.005 to 0.16<br>or<br>0.01 to 20 | 10 to 1 |
| Loss in weight (tank with control valve). | Most solutions | No slurries | 0.002 to 0.20 | 30 to 1 |
| Positive displacement: | | | | |
| Rotating dipper | Most solutions or slurries | | 0.1 to 30 | 100 to 1 |
| Proportioning pump: | | | | |
| Diaphragm | Most solutions. Special unit for 5% slurries.[1] | | 0.004 to 0.15 | 100 to 1 |
| Piston | Most solutions, light slurries. | | 0.01 to 170 | 20 to 1 |
| Gas feeders: | | | | |
| Solution feed | Chlorine | | 8000 lb/day max | 20 to 1 |
| | Ammonia | | 2000 lb/day max | 20 to 1 |
| | Sulfur dioxide | | 7600 lb/day max | 20 to 1 |
| | Carbon dioxide | | 6000 lb/day max | 20 to 1 |
| Direct feed | Chlorine | | 300 lb/day max | 10 to 1 |
| | Ammonia | | 120 lb/day max | 7 to 1 |
| | Carbon dioxide | | 10,000 lb/day max | 20 to 1 |

[1] Use special heads and valves for slurries.

## EXAMPLE 2 – INNOVATIVEPLANT PERSONNEL AND ALUM MAKE SUCCESSFUL PHOSPHORUS REMOVAL TEAM AT GRANDVILLE, MICHIGAN*

### INTRODUCTION

Grandville, Michigan was a community that relied on septic tanks until 1964. In 1964 a 1.6 MGD activated sludge plant was put into operation. It was expanded to 3.2 MGD in 1969 to incorporate Hudsonville, Georgetown, and Ottawa Townships. It was during this expansion that phosphorus removal equipment was added. The plant has an average flow of approximately 2.4 MGD.

### PHOSPHORUS REMOVAL EQUIPMENT

The City installed two 5,000 gallon fiberglass storage tanks, two 500 gallon fiberglass day storage tanks and two metering pumps. From the pump the coagulant is carried to the points of application in PVC lines suspended in conduits. By installing the feed lines in conduits, access for maintenance and ground warmth to prevent coagulant freezing are insured. From the PVC lines in the conduits, flexible rubber hosing carries the coagulant to the most effective point of application. The rubber hosing permits easy moving of the feed point to maximize particular coagulant efficiencies, and the ability to easily check coagulant feed into graduated cylinders (cc's per minute).

### CHEMICAL TREATMENT

A twenty-four hour profile of influent phosphorus values was made. Based on this profile, two chemical feed rates were established. From 11:00 p.m. to 8:00 a.m. the City found they could save money and chemicals by cutting the feed rate by 1/3 and still maintain the same level of phosphorus removal.

Chemical treatment began in December 1973 with the use of Ferric Chloride at a dose rate of 60 mg/l $FeCl_3$. Phosphorus removals ranging from 33.5% to 80% were experienced. On June 21, 1974, the City began the use of Liquid Aluminum Sulfate (Alum). An initial test dosage of 150 mg/l was found to be too high and was reduced to a range of 69-80 mg/l. From June 24, 1974 to the present, the City has met the 80% phosphorus removal requirement consistently with an average 82.8% removal (see Chart 1). Suspended solids removal increased from 82.3% to 91.4% average removal when they changed from ferric chloride to alum (see chart 2). The City splits the feed of alum in the primaries and secondaries during the summer to reduce the loading on the secondary stage. During the winter alum is added to the end of the activated sludge unit.

* Taken from Wastewater News, Allied Chemical Company

## INTERESTING NOTE

Mr. Glenn Folk, Superintendent of the facility, made note of the benefits of res[illegible] aluminum values in the recycle of his activated sludge. This is based on the observation that, during start-ups, high initial doses do not remove phosphorus as well as when the recycled sludge has built up an aluminum value. In fact, he noted that during a maintenance shutdown, the recycled sludge continued to remove phosphorus at high efficiencies for a period of time when the alum feed was discontinued. This is consistent with our observation that aluminum values in the recycle of activated sludge usually allow smaller alum dosages.

## CHLORINE SAVINGS

Before phosphorus removal began, the City used approximately 27 pounds of chlorine per million gallons to maintain a chlorine residual of 0.5 mg/l. Since the plant began the use of alum, they have been able to maintain the same 0.5 mg/l chlorine residual by using 19.6 pounds of chlorine per million gallons, for a chlorine savings of about 28%.

## SLUDGE

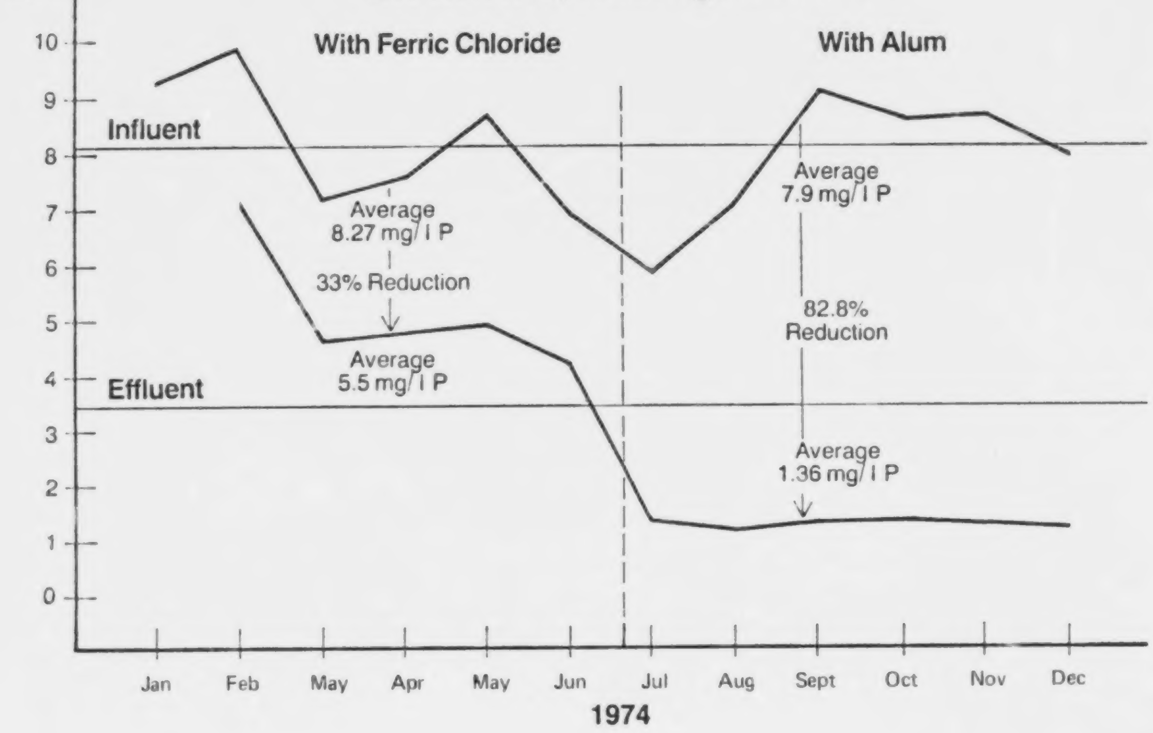
The primary sludge is treated by anaerobic digestion and the waste activated sludge is treated by aerobic digestion. Grandville has not experienced pH depression problems in either operation during alum usage, but two things were discovered. When alum is dosed in the primaries, the primary sludge became more homogenous and easier to handle. When dosed in the secondaries, the sludge going to the digestors increased in percent solids from 1% to 1.25% and sludge from the digestors increased to 5% solids, compared to 3% before alum use.

## MAINTENANCE

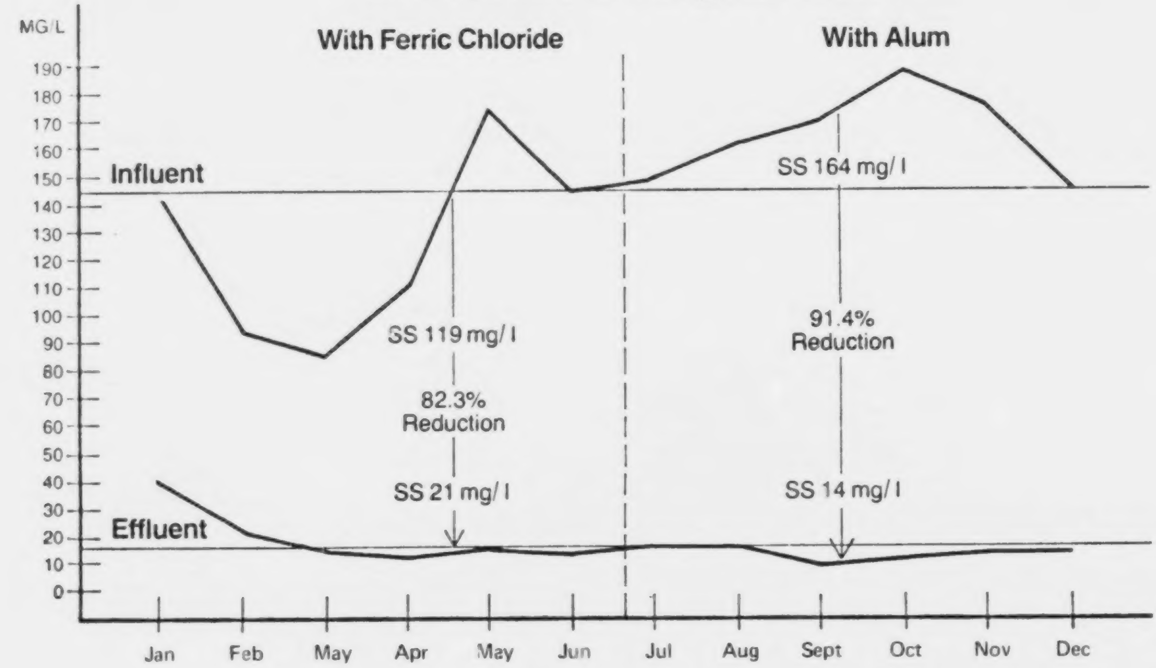
Grandville's good preventative maintenance program helps to keep the plant operating well. This program includes the regular flushing of lines and storage tanks to remove any possible accumulation of solids. Previous experience with solids accumulation led to this practice. Others may find this practice of value.

The innovations at Grandville's plant by Mr. Glenn Folk and his staff have resulted in a high degree of performance. We appreciate the opportunity to highlight his efforts and to publicize the excellent results.

## Chart #1
### Total Phosphorus and Percent Removal
### Grandville, Michigan Plant



## Chart #2
### Suspended Solids and Percent Removal
### Grandville, Michigan Plant



## REFERENCES – CHEMICAL ADDITIONS

Process Design Manual for Upgrading Existing Wastewater Treatment Plants. USEPA Technology Transfer, October 1974.

Process Design Manual for Suspended Solids Removal. USEPA Technology Transfer, January 1975.

Hall, M.W., and R. S. Engelbrecht. Phosphorus Removal – Past, Present, and Future. Water and Wastes Engineering, August 1969. pp 50-3.

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McAchran, E.G., and R. D. Hogue. Phosphate Removal from Municipal Sewage. Water & Sewage, February 1971. pp 36-9.

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Freese, P.V., E. Hicks, D.F. Bishop, and S.H. Griggs. Raw Wastewater Flocculations with Polymers at the District of Columbia Water Pollution Control Plant. Federal Water Quality Administration, Contract No. WPRD 53-01-67.

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Brown, J.C., L.W. Little, D.E. Francisco, and J.C. Lamb. Methods for Improvement of Trickling Filter Plant Performance, Part II. Alum Treatment Studies. USEPA, Contract No. 14-12-505, University of North Carolina, Chapel Hill, N.C., 1974.

Zenz, D.R., and J.R. Pivnicka. Effective Phosphorus Removal by the Addition of Alum to the Activated Sludge Process. Proceedings – 24th Industrial Waste Conference, Purdue University, pp 273-301, 1969.

Burns, D.E., and G.L. Shell. A New Approach to Phosphorus Removal by Chemical Treatment. Paper presented at: 45th Annual Water Pollution Control Federation Conference, Atlanta, Georgia, October 9, 1972.

Weber, W.J., Jr. Physiochemical Processes for Water Quality Control. John Wiley and Sons, Inc., New York, 1972.

Culp, G.L., et al. Physical-Chemical Wastewater Treatment Plant Design. USEPA Technology Transfer Seminar Publication, August 1973.

## LESSON: MANAGEMENT BEHAVIOR

### Index of Notebook Materials

| | | |
|---|---|---|
| MB – 1 | Management Troubleshooting Problem | Subdivision 2, Section II<br>Problem for solution by student groups. |
| MB – 2 | Student Group Answer Sheet No. 1 | Used by student groups to answer problem |
| MB – 3 | Student Group Answer Sheet No. 2 | Same as above |
| MB – 4* | Single Card Equipment Records System for a Small Plant | Reference by Instructor<br>Subdivision 2, Section III<br>Used to illustrate the development of a maintenance management system |
| MB – 5 & MB – 6* | Maintenance Scheduling – Daily and Weekly Routines | Same as above |
| MB – 7* | Sample Work Order | Same as above |
| MB – 8* | Sample Inventory Card | Same as above |
| MB – 9 & MB – 10* | Maintenance Organization Charts | Same as above |
| MB – 11* | Maintenance Cost Trend Form | Same as above |
| MB – 12 thru MB – 14* | Example Maintenance Management System | Same as above |
| MB – 15* | Computer Maintenance Program | Same as above |
| MB – 16 thru MB – 21* | Maintenance Management System Evaluation Guidelines | Subdivision 2, Section III<br>Reviewed by class in section on evaluating maintenance systems. |
| MB – 22 | References | |

Pages MB – 4 thru MB – 21 are reproduced from EPA Manual "Maintenance Management Systems for Municipal Wastewater Facilities."

## MANAGEMENT TROUBLESHOOTING PROBLEM

You are a state agency field inspector and have been called out to look at a three year old activated sludge plant that treats all of its waste sludge in a two-stage digester system. Grit is removed in a degritter ahead of the primary clarifier. Primary raw sludge is concentrated in a flotation thickener. Both sludges are fed into the digester by a pump operating on a time clock.

During the past year, the chief operator had experienced frequent primary digester upsets requiring lime additions. Upon inspecting the plant, you decided to graph the results of lab tests in order to form a clearer picture of what had been happening. The graph revealed erratic volatile acid to alkalinity ratios with each upward swing of volatile acid followed by a drop in pH at which point lime was added. The total amount of lime used was 40,000 lbs at a cost of $800 for the year.

You recommended to the chief operator that he should try to correct the condition and improve digester stability, while reducing operational costs, an idea the operator took kindly to. You then began to find out what the real problem causes were so that you could develop a plan to prevent their recurrence.

By listing all of the possible causes of digester upsets, you and the chief operator concluded that some type of overloading was the basic cause. Further "brainstorming" led you to believe that frequent overloading was due to one of the following six conditions.

1. Storm infiltration
2. Withdrawing too much seed sludge.
3. New sewer connection, particularly industry.
4. An industry with an occasional heavy discharge.
5. Sludge concentration too high at times.
6. Overpumping at times.

(Please turn to the next page.)

## MANAGEMENT TROUBLESHOOTING PROBLEM

### Student Group Answer Sheet No. 1

1. What would you look for next?

2. How would you narrow down the list of six possible causes?

3. Do you think that the problem may be due to other causes?

# MANAGEMENT TROUBLESHOOTING PROBLEM

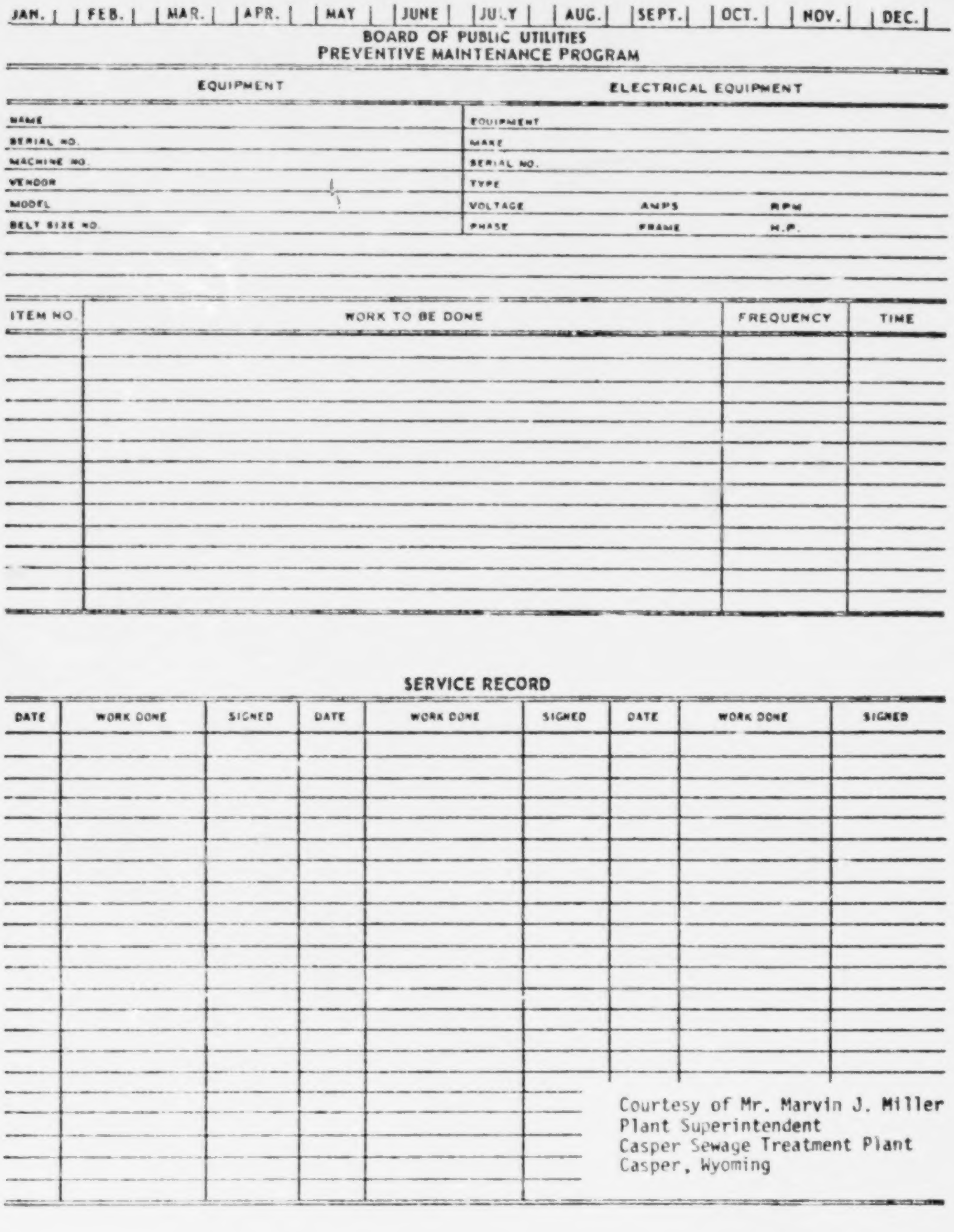
## Student Group Answer Sheet No. 2

1. Which corrective action would *you* recommend as the troubleshooter in this problem?

2. How would you implement the action that you recommend?

3. Why didn't you get the right answer the first time around?

Title: Single Card Equipment Records
System for a Small Plant



JAN. | FEB. | MAR. | APR. | MAY | JUNE | JULY | AUG. | SEPT. | OCT. | NOV. | DEC.

BOARD OF PUBLIC UTILITIES
PREVENTIVE MAINTENANCE PROGRAM

| EQUIPMENT | ELECTRICAL EQUIPMENT |
|---|---|
| NAME | EQUIPMENT |
| SERIAL NO. | MAKE |
| MACHINE NO. | SERIAL NO. |
| VENDOR | TYPE |
| MODEL | VOLTAGE AMPS RPM |
| BELT SIZE NO. | PHASE FRAME H.P. |

| ITEM NO. | WORK TO BE DONE | FREQUENCY | TIME |
|---|---|---|---|

SERVICE RECORD

| DATE | WORK DONE | SIGNED | DATE | WORK DONE | SIGNED | DATE | WORK DONE | SIGNED |
|---|---|---|---|---|---|---|---|---|

Courtesy of Mr. Marvin J. Miller
Plant Superintendent
Casper Sewage Treatment Plant
Casper, Wyoming

## DAILY ROUTINE

NOTE:

1. SAFETY FIRST SHALL BE STRICTLY OBSERVED.
2. WORK AREAS SHALL BE KEPT CLEAN AT ALL TIMES. (WASHED & DISINFECTED)
3. ANYTHING UNUSUAL SHOULD BE REPORTED.

### Wailoa and Pua Pump Stations

1. Make visual inspection
2. Check pump packing
3. Check sump pump-oil
4. Check flo-matcher water level and temperature
5. Alternate variable speed motors manually
6. Bleed air receiver tank (s)

### Sub Stations

Hilo

1. Clean grating (Hose down)
2. Visual check: Pump packing-sump pump

Peninsula

1. Bleed compressor tank
2. Check sump pump

Keaukaha

1. Bleed compressor tank
2. Check sump pump

### Treatment Plant

Grit Chamber

1. Grind rags and wash down
2. Visual inspect sprayer nozzles
3. Remove grit once a week

Clarifier

1. Hose down as required scum pit
2. Hose down
3. Pump out

Sludge Pump Building

1. Check sump pump
2. Visual check
3. Check sludge pump-oil level

Courtesy of Mr. Harold Sugiyama
Bureau of Sewers & Sanitation
Hilo Sewage Treatment Plant
Hilo, Hawaii

## ROUTINE DUTIES — TO BE SCHEDULED BY FOREMAN

### Weekly

Grit Chamber

Remove sediments and floating solids

Sludge Centrifuge Building

1. Check centrifuge torque converter oil level
2. Remove sludge (Run centrifuge with water if sludge is not removed)

### Monthly

Sludge Pump Building

1. Grease air compressor bearings
2. Clean air filter

Wailoa Pump Station

1. Check compressor oil level
2. Clean air filter

### General Duties

January and July

Pua Station

Grease—all bearings

1. Electric motor bearing
2. Drive shaft bearing
3. Pump bearing
4. Change packing as required (complete)
5. Exercise all valves — grease shaft
6. Wash floors as required

Sludge Centrifuge Building

Grease all bearings

February and August

Wailoa Pump Station

Grease all bearings

1. Electric motor
2. Pump drive shaft
3. Pump
4. Change packing as required (complete)
5. Exercise all valves — grease shaft
6. Wash floors as required

Courtesy of Mr. Harold Sugiyama
Bureau of Sewers & Sanitation
Hilo Sewage Treatment Plant
Hilo, Hawaii

Date ______________

Work Order No. ______________________________

| | | |
|---|---|---|
| Location | Requested By:<br>(Phone) | Priority: |

| Equipment Name | No. |
|---|---|
| | |
| | |
| | |
| | |
| | |
| | |
| | |
| | |
| | |
| | |

☐ Inspect ☐ Replace ☐ Service

☐ Repair ☐ Overhaul ☐ Paint

Work Description

Work Performed/Comments

______________________________
Maintenance Superintendent

Job Estimate

Labor $ ______________

Material $ ______________

Work Record

| Personnel Assigned | Manhours | Date | Work Done | Parts & Materials |
|---|---|---|---|---|
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| Total | | | | |

Work Completed By ______________________________ Date ____________

Work Accepted By ______________________________ Date ____________

SAMPLE: WORK ORDER

STOREROOM INVENTORY CARD

Item No. ________

Item Description -

Isle No. ________

Bin No. ________

Quantity Maximum ________________ Minimum ________________

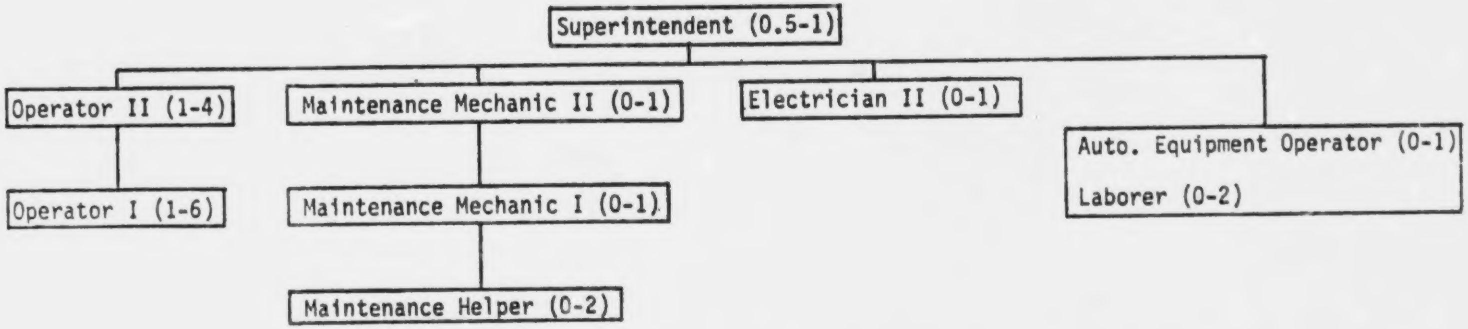
Reorder ________________

INVENTORY INFORMATION

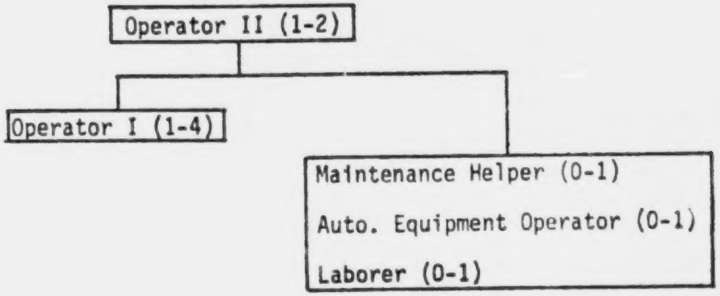
| Quantity Used or Stocked | Date | Signed | Quantity on Hand | USAGE OR SUPPLY INFORMATION<br>Usage - Work Order No.<br>Supply - Purchase Order No. |
|---|---|---|---|---|
| | | | | |

SAMPLE INVENTORY CARD

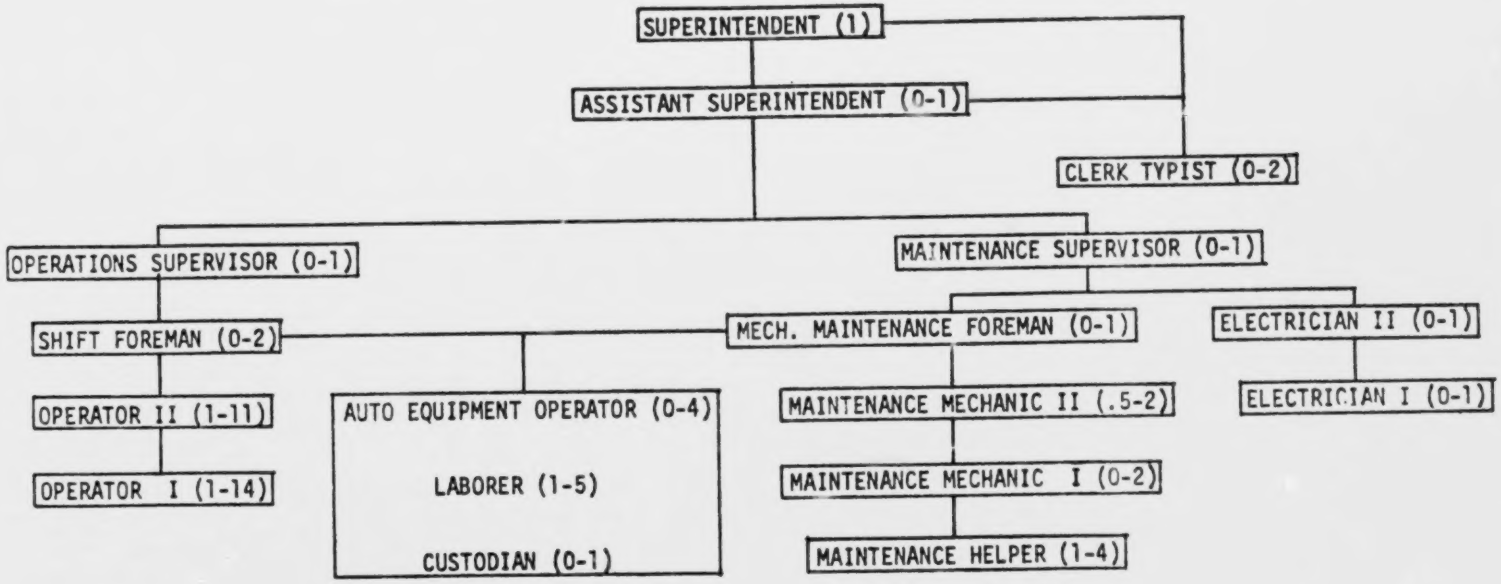
MAINTENANCE ORGANIZATIONAL CHART NO. 1


Superintendent (0.5-1)
Operator II (1-4)
Operator I (1-6)
Maintenance Mechanic II (0-1)
Maintenance Mechanic I (0-1)
Maintenance Helper (0-2)
Electrician II (0-1)
Auto. Equipment Operator (0-1)
Laborer (0-2)

MAINTENANCE ORGANIZATIONAL CHART NO. 2


Operator II (1-2)
Operator I (1-4)
Maintenance Helper (0-1)
Auto. Equipment Operator (0-1)
Laborer (0-1)

Maintenance Organizational Charts - Plant Size: 10 MGD or Less

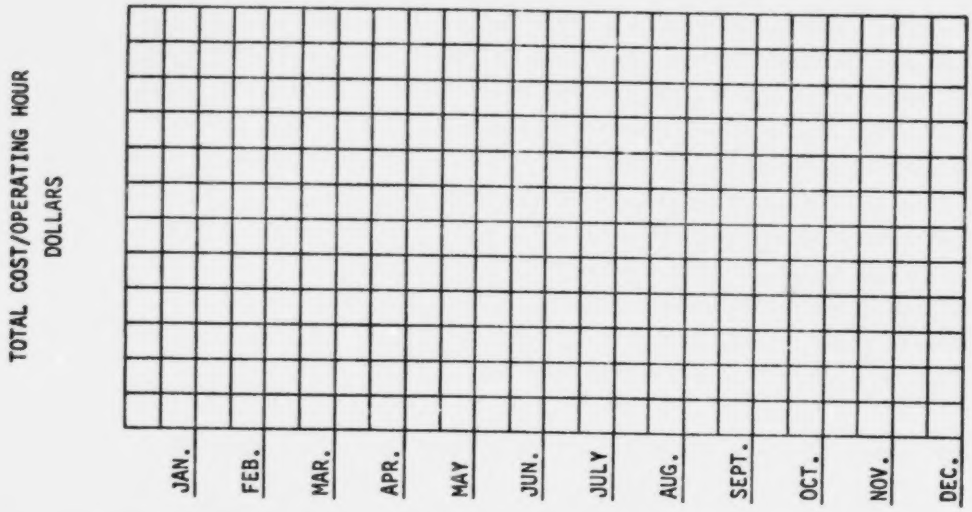

SUPERINTENDENT (1)
ASSISTANT SUPERINTENDENT (0-1)
CLERK TYPIST (0-2)
OPERATIONS SUPERVISOR (0-1)
MAINTENANCE SUPERVISOR (0-1)
SHIFT FOREMAN (0-2)
MECH. MAINTENANCE FOREMAN (0-1)
ELECTRICIAN II (0-1)
ELECTRICIAN I (0-1)
OPERATOR II (1-11)
OPERATOR I (1-14)
AUTO EQUIPMENT OPERATOR (0-4)
LABORER (1-5)
CUSTODIAN (0-1)
MAINTENANCE MECHANIC II (.5-2)
MAINTENANCE MECHANIC I (0-2)
MAINTENANCE HELPER (1-4)

Maintenance Organizational Chart - Plant Size: 10 MGD to 50 MGD

## MAINTENANCE COST TREND FORM

EQUIPMENT NAME ____________________ LOCATION ____________________

I.D. NO. ____________________



| MAINT. COST/HOUR $ ____ DATE | OPN. HOURS | REPAIR LABOR HOURS | PM LABOR HOURS | TOTAL LABOR HOURS | MAT'L COST | LABOR COST PER OPN. HOUR | MAT'L COST PER OPN. HOUR | TOTAL COST PER OPN. HOUR |
|---|---|---|---|---|---|---|---|---|
| JAN. | | | | | | | | |
| FEB. | | | | | | | | |
| MAR. | | | | | | | | |
| APR. | | | | | | | | |
| MAY | | | | | | | | |
| JUN. | | | | | | | | |
| JULY | | | | | | | | |
| AUG. | | | | | | | | |
| SEP. | | | | | | | | |
| OCT. | | | | | | | | |
| NOV. | | | | | | | | |
| DEC. | | | | | | | | |

REMARKS ____________________

# CORRELATION OF THE BASIC SYSTEM FEATURES INTO A WORKING MAINTENANCE MANAGEMENT SYSTEM

## General

This section provides examples of maintenance management systems for various size plants. The following three examples are for a small facility, a middle size facility, and a large facility. The examples assume all facilities are properly staffed and are operating continuously. The example maintenance systems for the three size facilities are all workable systems. However, they are not intended to be rigid formats for all facilities within a given size range. In developing a system for a particular plant, a person may use any combination of the feature techniques from larger or smaller plants and may adapt them to his particular plant. Because various procedures can be used in a variety of plants, no size range has been assigned to these examples. A person preparing a new system or updating an existing system can use these examples to help develop the maintenance management system which best fits his particular plant.

Each example is broken down into the five basic features of a maintenance management system. This breakdown corresponds to this manual's format which has a separate section on each of these five basic features. This permits persons reviewing these examples of maintenance management systems to quickly refer to the appropriate section in this manual for a discussion of any item described in the examples.

Note: Included are the first three pages of an extensive section
on developing maintenance management systems.

Reproduced from Chapter IX, "Maintenance Management Systems for
Municipal Wastewater Facilities".

## PLANNING & SCHEDULING
(CONTINUED)

| EVALUATION GUIDELINES | MAX. RATING | YOUR RATING |
|---|---|---|
| a. Are PM frequencies based upon manufacturers' recommendations and by inspection? | 10 | |
| b. Does the existing maintenance organization permit the proper scheduling of required PM and take into account the corrective maintenance demands on the maintenance force? | 10 | |
| 3. Are potential corrective maintenance tasks adequately considered in maintenance planning? | 20 | |
| 4. Do you have a work order system that satisfies the treatment system's maintenance requirements? | 30 | |
| 5. Are manpower management techniques used effectively to obtain maximum utilization? | 30 | |
| 6. Do you have some form of labor standards to assist in preparing accurate work estimates for repetitive maintenance jobs? | 30 | |
| 7. Have you contracted for maintenance tasks beyond the capability of your staff and determined the availability of this support? | 20 | |
| TOTAL | 200 | |

## EXAMPLE MAINTENANCE MANAGEMENT SYSTEM
(Continued)

### SMALL FACILITY

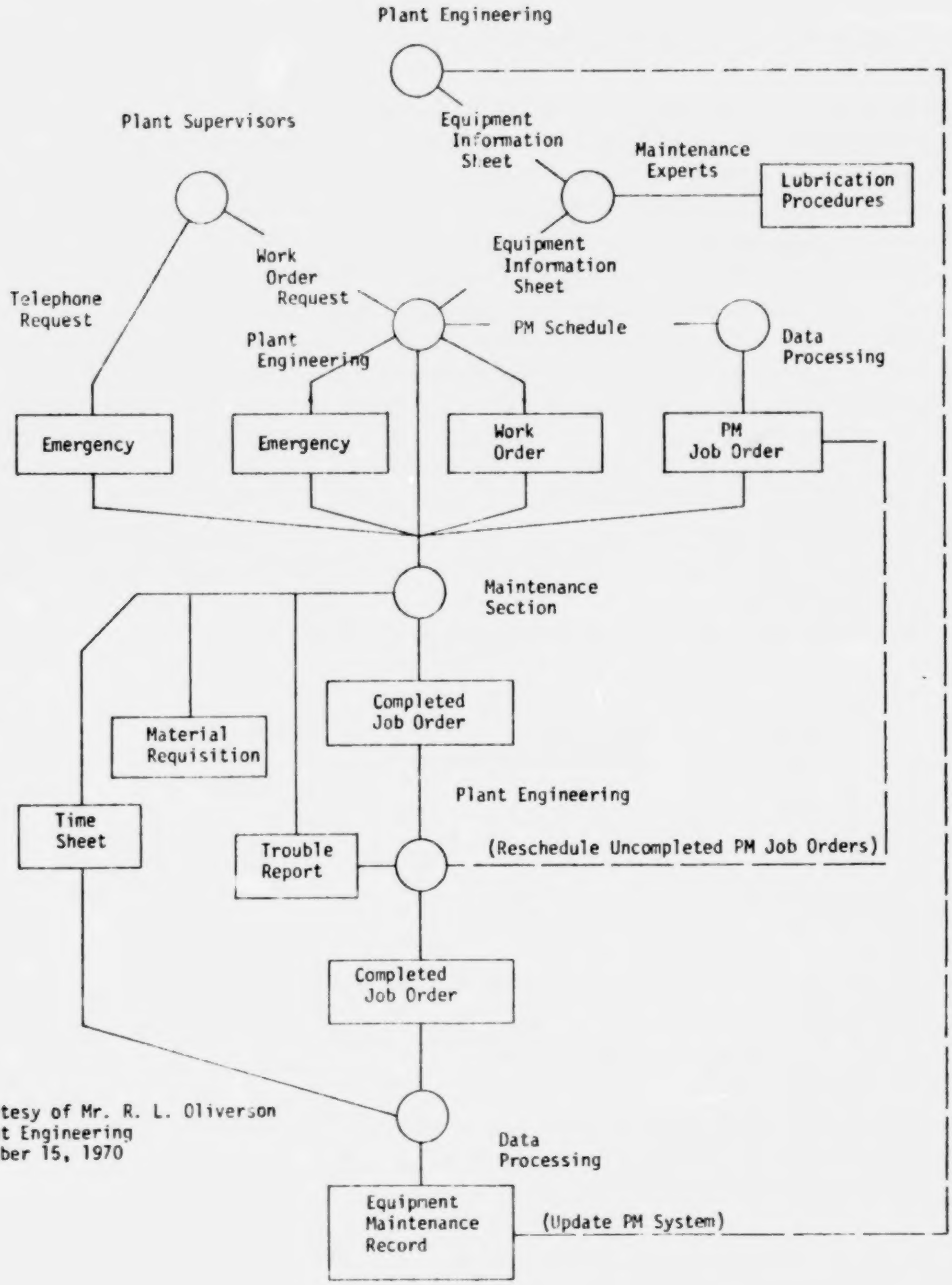
| Number | Equipment Description |
|---|---|
| 10 | Primary Sedimentation Tank |
| 11 | Sludge Collection Mechanism |
| • | • |
| • | • |
| • | • |
| 35 | Aeration Tank |
| 36 | Aerator No. 1 |
| • | • |
| • | • |
| • | • |
| 42 | Final Clarifier |
| 43 | Sludge Collection Mechanism |
| • | • |
| • | • |
| 49 | Chlorine Contact Tank |
| • | • |
| • | • |
| 58 | Raw Sludge Pump No. 1 |
| • | • |
| • | • |
| 63 | Primary Digester |
| 64 | Primary Digester Stirring Mechanism |
| 72 | Sludge Drying Beds |
| • | • |

### MIDDLE SIZE FACILITY

| Number | Equipment Description |
|---|---|
| 101-150 | Aeration Tanks |
| 101 | Aeration Tank No. 1 |
| 102 | Mechanical Mixer No. 1 |
| 103 | • |
| • | • |
| 151-175 | Final Clarifiers |
| 151 | Final Clarifier No. 1 |
| 152 | Sludge Collection Mechanism |
| 153 | • |
| • | • |
| 176-250 | Operations Building |
| • | • |
| • | • |
| 251-275 | Chlorine Contact Tank |
| 251 | • |
| • | • |
| 276-300 | Sludge Thickener |
| 276 | • |
| • | • |
| 301-325 | Digester and Sludge Gas System |
| 301 | • |
| • | • |
| 326-350 | Centrifuges |
| 326 | • |
| • | • |

### LARGE FACILITY

| Number | Equipment Description |
|---|---|
| 2000 | Primary Treatment Structur |
| 2100 | Primary Sedimentation |
| 2110 | Influent Manifold |
| 2120 | Primary Sedimentation Tank No. 1 |
| 2121 | Valve No. 1 |
| 2122 | • |
| 2130 | Primary Sedimentation Tank No. 2 |
| 2131 | • |
| 2132 | • |
| 2200 | Boiler Room |
| 2210 | Raw Sludge and Scum, Pumping System |
| 2211 | Raw Sludge Pump No. 1 |
| 2212 | • |
| 2213 | • |
| 2220 | Digested Sludge Recirculation System |
| 2221 | Sludge Recirculation Pump No. 1 |
| 2222 | • |
| 2300 | Control Room |
| 2310 | Motor Control Center No. 1 |
| 2320 | High Pressure Air System |
| 2321 | Compressor |


Plant Engineering
Plant Supervisors
Equipment Information Sheet
Maintenance Experts
Lubrication Procedures
Equipment Information Sheet
Work Order Request
Telephone Request
Plant Engineering
PM Schedule
Data Processing
Emergency
Emergency
Work Order
PM Job Order
Maintenance Section
Completed Job Order
Material Requisition
Plant Engineering
Time Sheet
Trouble Report
(Reschedule Uncompleted PM Job Orders)
Completed Job Order
Data Processing
Equipment Maintenance Record
(Update PM System)

Courtesy of Mr. R. L. Oliverson
Plant Engineering
October 15, 1970

CLOSED SYSTEM COMPUTER MAINTENANCE PROGRAM

## MAINTENANCE MANAGEMENT SYSTEM EVALUATION GUIDELINES

This section is to aid persons developing maintenance management systems by providing a checklist for evaluating a proposed system and to aid treatment plant management in evaluating an existing maintenance management system. The evaluation guidelines are broken down into the five basic maintenance features considered essential to a maintenance management system. A maximum of two hundred (200) points have been allotted to each feature, thus a maximum score of one thousand (1000) points is possible. In reviewing a system, the evaluator must remember these guidelines apply to all types and sizes of treatment plants. Due to the range of plant sizes and their complexities, no minimum passing score has been given. The purpose of these guidelines is to aid in locating problem areas so they may be corrected or improved. An individual using these evaluation guidelines will generally find the maintenance system he is analyzing does possess most of the features outlined in the Guidelines. However, there will probably be many qualifications accompanying each positive response to the questions in the Guidelines. This is true because the features of many maintenance systems are either incomplete or are incapable of performing their intended function. Each question in the Evaluation Guidelines should be carefully weighed and given a rating commensurate with the feature's ability to perform its role in the total maintenance management system.

### EQUIPMENT RECORD SYSTEM

| EVALUATION GUIDELINES | MAX. RATING | YOUR RATING |
|---|---|---|
| 1. Do you have an equipment numbering or other identification system to aid in locating and identifying all major items of equipment? | 20 | |
| 2. Do you have a system for maintaining nameplate data and other essential information on all major equipment items within the treatment system? | 50 | |
| 3. Does your maintenance record system provide for listing preventive maintenance (PM) tasks, giving their frequency and recording the PM work performed? | 30 | |

## EQUIPMENT RECORD SYSTEM
## (CONTINUED)

| EVALUATION GUIDELINES | MAX. RATING | YOUR RATING |
|---|---|---|
| 4. Does your maintenance record system provide for recording corrective maintenance work performed? | 20 | |
| 5. Does your maintenance record system provide for recording such information as maintenance manhours, spare parts or components used in repair and name of individual performing each job? | 30 | |
| 6. Does your maintenance record system provide for recording all maintenance related costs and can these costs be readily compiled for use in maintenance budget preparation? | 30 | |
| 7. Are miscellaneous maintenance related documents such as as-built drawings, construction specifications and photos, shop drawings and manufacturers' literature properly filed and indexed and readily available to maintenance staff? | 20 | |
| TOTAL | 200 | |

## PLANNING AND SCHEDULING

| EVALUATION GUIDELINES | MAX. RATING | YOUR RATING |
|---|---|---|
| 1. Is some form of schedule chart or priority list provided to assist maintenance supervisors in controlling maintenance tasks? | 20 | |
| 2. Do you plan and schedule preventive maintenance (PM) tasks for all major equipment items within the treatment system? | 30 | |

## PLANNING & SCHEDULING
(CONTINUED)

| EVALUATION GUIDELINES | MAX. RATING | YOUR RATING |
|---|---|---|
| a. Are PM frequencies based upon manufacturers' recommendations and by inspection? | 10 | |
| b. Does the existing maintenance organization permit the proper scheduling of required PM and take into account the corrective maintenance demands on the maintenance force? | 10 | |
| 3. Are potential corrective maintenance tasks adequately considered in maintenance planning? | 20 | |
| 4. Do you have a work order system that satisfies the treatment system's maintenance requirements? | 30 | |
| 5. Are manpower management techniques used effectively to obtain maximum utilization? | 30 | |
| 6. Do you have some form of labor standards to assist in preparing accurate work estimates for repetitive maintenance jobs? | 30 | |
| 7. Have you contracted for maintenance tasks beyond the capability of your staff and determined the availability of this support? | 20 | |
| TOTAL | 200 | |

## STOREROOM AND INVENTORY SYSTEM

| EVALUATION GUIDELINES | MAX. RATING | YOUR RATING |
|---|---|---|
| 1. Have you provided a storeroom or storage area to assist in controlling the flow of spare parts, components and maintenance supplies? | 40 | |
| 2. Have you reviewed manufacturers' recommendations and studied each major equipment item's maintenance requirements to determine what maintenance items should be maintained? | 40 | |
| a. Have you developed a system to monitor quantities of all maintenance items kept in stock? | 20 | |
| b. Have you established minimum and maximum quantities for all maintenance items kept in stock? | 20 | |
| c. Do you have a purchase order system that adequately controls the procuring of maintenance items? | 20 | |
| 3. Do you have system for locating a given item in the storeroom? | 20 | |
| 4. Do you have a catalog or index system to assist in identifying and locating a given item in the storeroom? | 20 | |
| 5. Do you have a storeroom ticket or withdrawal slip to use when maintenance items are taken from stock? | 20 | |
| TOTAL | 200 | |

## MAINTENANCE ORGANIZATION & PERSONNEL

| EVALUATION GUIDELINES | MAX. RATING | YOUR RATING |
|---|---|---|
| 1. Do you have a maintenance organization chart that satisfies treatment system requirements? | 30 | |
| 2. Is your maintenance organization chart reviewed and updated as required? | 20 | |
| 3. Do you have job descriptions for each job title within your maintenance organization? | 30 | |
| 4. Are job descriptions kept up to date and made available to maintenance personnel as required? | 20 | |
| 5. Prior to initiating any program to correct deficiencies in a maintenance job, is a thorough analysis of this job performed? | 50 | |
| 6. Do you have a maintenance training program that satisfies the maintenance objectives of the treatment system? | 50 | |
| TOTAL | 200 | |

## COST AND BUDGETS FOR MAINTENANCE OPERATIONS

| EVALUATION GUIDELINES | MAX. RATING | YOUR RATING |
|---|---|---|
| 1. Are maintenance costs broken down by maintenance categories such as preventive maintenance, corrective maintenance and major repairs or alterations? | 50 | |
| 2. Do you have a system of cost codes or charge numbers for allocating labor and materials to specific maintenance jobs? | 40 | |

## COST AND BUDGETS FOR MAINTENANCE OPERATIONS
(CONTINUED)

| EVALUATION GUIDELINES | MAX. RATING | YOUR RATING |
|---|---|---|
| 3. Do you have a system for recording the maintenance cost history of all major equipment items? | 30 | |
| 4. Do you have a system for compiling cost information for use in budget preparation and maintenance cost studies? | 50 | |
| 5. Do you have a system for recording contract maintenance costs so they can be used in preparing maintenance budgets? | 30 | |
| TOTAL | 200 | |

Persons using these Evaluation Guidelines should follow up the evaluation with a review of the areas receiving the lowest ratings. It should be remembered that an apparent weak area may be due to another system feature performing poorly and pulling the weak area down.

The questions in the Evaluation Guidelines are grouped into the five basic maintenance features. Individuals can review the section of the manual which discusses each basic feature when they find deficiencies in the maintenance system they are analyzing. The information contained in the manual should assist persons in correcting the weaknesses in their maintenance management system.

It should be recognized that several of the questions in the Evaluation Guidelines deal with items that are absolutely essential to the success of any maintenance management system. These critical items include an equipment identification system, planning and scheduling preventive maintenance tasks, control of spare parts and supplies, and a system for preparing maintenance budgets. Maintenance management systems that receive low ratings in any of these critical areas should be considered deficient and appropriate corrective actions taken.

## REFERENCES – MANAGEMENT BEHAVIOR

Maintenance Management Systems for Municipal Wastewater Facilities. USEPA Office of Water Programs Operations, 1973.

Estimating Staffing for Municipal Wastewater Treatment Facilities. USEPA Office of Water Programs Operations, 1973.

Hayes, R.B., Operator's Guide to Management and Supervision. Stevens, Thompson & Runyan, Inc., Portland, 1975.

Bittel, What Every Supervisor Should Know. McGraw Hill.

American Management Association. Supervisory Effectiveness – A home study course.

Water Pollution Control Federation. Manual of Practice No. 1. Safety in Wastewater Works.

Emergency Planning for Municipal Wastewater Treatment Facilities. USEPA.

Equal Employment Opportunity Commission. Affirmative Action and Equal Employment. Guidebook for Employers.

Handy Reference Guide to the Fair Labor Standards Act. U.S. Department of Labor.

Water Pollution Control Federation. Manual of Practice No. 10. Uniform System of Accounts for Wastewater Utilities.

Water Pollution Control Federation. Manual of Practice No. 12. The Public Relations Handbook.

# LESSON: ACTIVATED SLUDGE

## Index of Notebook Materials

| PAGES | MATERIAL | USE IN LESSON |
|---|---|---|
| AS – 1 | Activated Sludge Control Strategy Cases | Reference by Instructor Subdivision 1, Section V |
| AS 2 – 9 | Checklist for Process Evaluation | Reference by Instructor Subdivision 1, Section VI |
| AS 10 thru AS – 13 | Process Flow Diagrams | Reference by Instructor, Subdivision 1, Section VII |
| AS 14 – 18 | Supplemental Information on Control Concepts | Additional Information Provided to Students |
| AS – 19 | Additional Information for Troubleshooting Problems | Reference by Instructor Subdivision 3, Section VIII |
| AS 20 thru 22 | Hamsborough Troubleshooting Problem – Part I | Subdivision 5, Section I<br>Used by students to solve problem |
| AS – 23 | Answer Sheet – Hamsborough Troubleshooting Problem | Subdivision 5, Section II |
| AS – 24 thru 36 | Pullman Troubleshooting Problem | Subdivision 6 – Used by students to solve and review problem |
| AS 37 thru 39 | Studies & Tables on Package Plants | Reference by Instructor Subdivision 8, Section III |
| AS – 40 | Troubleshooting Guide – Extended Aeration Plants | Reference by Instructor Subdivision 8, Section IV |
| AS – 41 | Package Plant Checklist | Same as above |
| AS – 42 46 | Flow Diagrams – Package Plants | Reference by Instructor Subdivision 8, Section I |
| AS – 47 | References | |

## ACTIVATED SLUDGE CONTROL STRATEGY CASES

1. *Case I:* Assume that the hydraulic and organic loads to the aeration basin remain constant. Settleometer test results indicate that the sludge is beginning to settle more slowly and return sludge concentrations are decreasing. Indicate below what the expected change in each parameter would be:

   a. F/M
   b. MCRT
   c. Respiration rate of the MLSS

   Indicate below the control actions that would probably be required

   a. Return sludge flow rate
   b. Waste sludge rate

2. *Case II:* Assume that the hydraulic load to the aeration basin remains constant and that the organic load increases. Assume that no changes have been made in return rates or in wasting practices. Indicate below the expected change in each parameter.

   a. Sludge settling rate
   b. Sludge blanket depth
   c. F/M
   d. MCRT
   e. Respiration rate of the MLSS
   f. Aeration basin DO

   Indicate below the control actions that would probably be required:

   a. Return sludge rate
   b. Waste sludge rate
   c. Air supply rate

3. *Case III:* Assume that the hydraulic flow to the aeration basin increases while the organic load remains constant. Indicate below what the expected change in each parameter would be:

   a. MLSS concentration
   b. F/M
   c. MCRT
   d. Respiration rate of the MLSS
   e. Sludge settling rate
   f. Sludge blanket depth

   Indicate below the probable control actions that would be required

   a. Sludge return rate
   b. Waste sludge rate

## ACTIVATED SLUDGE PROCESS EVALUATION

### Treatment Facilities

**PLANT NAME** ______________________ **SUPERVISOR** ____________

**Location – City** ______________________ **State** ____________

**Phone No.** ____________________

**DATE OR PERIOD** ______________________

OPERATING MODE
(Step, Complete Mix, etc.) . . . . . . . . . . . . . . . . . . . .

AERATION TANKS
(Air, $O_2$, Mech., etc) . . . . . . . . . . . . . . . . . . . . .

No. of Tanks Available . . . . . . . . . . . . . . . . . . . . .
No. of Passes/Tank . . . . . . . . . . . . . . . . . . . . . .
Tank Dimensions . . . . . . . . . . . . . . . . . . . . . . .
ASA – Surface Area/Tank (sq ft) . . . . . . . . . . . . . . . .
AVF – Volume/Tank (cu ft) . . . . . . . . . . . . . . . . . .
AVG. – Volume/Tank (gals) . . . . . . . . . . . . . . . . . .

No of Tanks in Service . . . . . . . . . . . . . . . . . . . .
ASA – Total Surface Area (sq ft) . . . . . . . . . . . . . . . .
AVF – Total Volume (cu ft) . . . . . . . . . . . . . . . . . .
AVG. – Total Volume (gals) . . . . . . . . . . . . . . . . . .

FINAL CLARIFIERS
(Rectangular or Circular)
(Center or Peripheral Feed)
(Effluent Launder Arrangement)
(Sludge Mech. – Plows, Suction, etc) . . . . . . . . . . . .

No. of Tanks Available . . . . . . . . . . . . . . . . . . . .
Tank Demensions . . . . . . . . . . . . . . . . . . . . . . .
CSA – Surface Area/Tank (sq ft) . . . . . . . . . . . . . . . .
CVF – Volume/Tank (cu ft) . . . . . . . . . . . . . . . . . .

No. of Tanks in Service. . . . . . . . . . . . . . . . . . . .
CSA – Total Surface Area (sq ft) . . . . . . . . . . . . . . . .
CVF – Total Volume (cu ft) . . . . . . . . . . . . . . . . . .
CVG – Total Volume (gals) . . . . . . . . . . . . . . . . . .

**PLANT NAME** ______________________ **SUPERVISOR** __________

**Location – City** ______________________ **State** __________

**Phone No.** ______________

**DATE OR PERIOD** ______________

AERATION EQUIPMENT – DIFFUSED AIR
Diffusers
 (Spargers, Plates, etc)
 (Diffuser Placement – Spacing) . . . . . . . . . . . . . . . . . .

Blowers
 (Type – Centrif., Positive Displacement, etc) . . . . . . . . . .
No. Available . . . . . . . . . . . . . . . . . . . . . . . . . .
Total SCFM Available . . . . . . . . . . . . . . . . . . . . . .

AERATION EQUIPMENT – MECHANICAL
 (Surface, Turbine, etc)
 (Adjustable Speed or Weirs?) . . . . . . . . . . . . . . . . . .
No. of Aerators Available . . . . . . . . . . . . . . . . . . . .
HP per Aerator . . . . . . . . . . . . . . . . . . . . . . . . .
Total HP Available . . . . . . . . . . . . . . . . . . . . . . .

RETURN SLUDGE PUMPS
Type (Centrif., Airlift, etc) . . . . . . . . . . . . . . . . . .
 (Variable or Constant) . . . . . . . . . . . . . . . . . . . . .
No. of pumps . . . . . . . . . . . . . . . . . . . . . . . . . .
Capacity – MGD/pump . . . . . . . . . . . . . . . . . . . . . .
Total Available Capacity (MGD) . . . . . . . . . . . . . . . . .

WASTE SLUDGE PUMPS
Manifold from Return? . . . . . . . . . . . . . . . . . . . . .
Separate Pumps? . . . . . . . . . . . . . . . . . . . . . . . .
Type (Centrif., Piston, etc) . . . . . . . . . . . . . . . . . .
 (Variable or Constant) . . . . . . . . . . . . . . . . . . . . .
No. of Pumps . . . . . . . . . . . . . . . . . . . . . . . . . .
Capacity – MGD/pump . . . . . . . . . . . . . . . . . . . . . .
Total Available Capacity (MGD) . . . . . . . . . . . . . . . . .
Suction from ML and/or Clar. Sl. Piping . . . . . . . . . . . . .

**PLANT NAME** ______________________________ **SUPERVISOR** __________

**Location – City** ______________________________ **State** ______________

**Phone No.** ______________________

**DATE OR PERIOD** ____________________________

FLOW METERS
Describe
(Are ranges and accuracy OK?) . . . . . . . . . . . . . . . . . .
Locations, Types
(totalizers, chart recorders, etc) . . . . . . . . . . . . . . . . . .
Other sensors
(DO, pH, Sl. conc., etc) . . . . . . . . . . . . . . . . . . . . .

CONTROLLERS
Describe . . . . . . . . . . . . . . . . . . . . . . . . . . . .
Automatic Controllers, if any . . . . . . . . . . . . . . . . . . . .

## ACTIVATED SLUDGE PROCESS EVALUATION

### Secondary Process Loadings

**PLANT NAME** ______________________________ **SUPERVISOR** __________

**Location – City** ______________________________ **State** ______________

**Phone No.** ________________________

**DATE OR PERIOD**
**(Daily, Weekly or Monthly Averages)** . . . . . . . . . . . . . .

AFI – INFLUENT TO SECONDARY PROCESS
Average Flow (MGD) . . . . . . . . . . . . . . . . . . . . . . . .
$BOD_5$ (mg/l) . . . . . . . . . . . . . . . . . . . . . . . . . .
$BOD_5$ (lbs/day) . . . . . . . . . . . . . . . . . . . . . . . .
TSS(mg/l) . . . . . . . . . . . . . . . . . . . . . . . . . . . .
TSS (lbs/day) . . . . . . . . . . . . . . . . . . . . . . . . . .
RSF – Return Sludge Flow (MGD) . . . . . . . . . . . . . . . .
RSP – Return Sludge Flow Percentage
(% of AFI)

SLUDGE CHARACTERISTICS
(Mixed Liquor)
MLTSS (mg/l) . . . . . . . . . . . . . . . . . . . . . . . . . .
ATC – Aeration Tank Conc. (%) . . . . . . . . . . . . . . . . .
WCR – MLTSS/ATC . . . . . . . . . . . . . . . . . . . . . . . .
% Volatile . . . . . . . . . . . . . . . . . . . . . . . . . . . .

AERATION TANK LOADINGS
(Hydraulic)
ADT @ AFO – Aeration Detention Time @ Waste Flow
ADT @ TFL – Aeration Detention Time @ Influent
Flow + Return (hrs) . . . . . . . . . . . . . . . . . . . . . .
ASDT – A.T. Sludge Detention Time (hrs) . . . . . . . . . . .
AWDT – A.T. Waste Detention Time (hrs) . . . . . . . . . . .

(Organic)
lbs. $BOD_5$/1,000 cu ft Aer. Tank . . . . . . . . . . . . . . .
F/M – lbs $BOD_5$/lb MLVSS . . . . . . . . . . . . . . . . . .

(Aeration Intensity)
- Mech. or Turbine

HP Applied . . . . . . . . . . . . . . . . . . . . . . . . . . . .
HP/1,000 sq ft Aer. Surface Area . . . . . . . . . . . . . . . .
HP – Hr/lb $BOD_5$ . . . . . . . . . . . . . . . . . . . . . . .
lb $O_2$/hp-hr

**PLANT NAME** ______________________________ **SUPERVISOR** ____________

**Location – City** ______________________________ **State** ____________

**Phone No.** ______________________

**DATE OR PERIOD**
**(Daily, Weekly or Monthly Averages)** . . . . . . . . . . . . . .

- Atmospheric Air

SCFM – Applied . . . . . . . . . . . . . . . . . . . . . . . . .
SCFM/1,000 sq ft Aer. Surface Area . . . . . . . . . . . . . . .
cu ft/gal (Domestic Wastewater Treated) . . . . . . . . . . . .
cu ft/lb BOD removed . . . . . . . . . . . . . . . . . . . . .

FINAL CLARIFIER LOADINGS
(Hydraulic)
CDT – Final Clar. Detention Time (hrs) . . . . . . . . . . . . .
OFR – F.C. Surface Overflow Rate (gpd/sq ft) . . . . . . . . .
Weir Overflow Data (gpd/lin ft) . . . . . . . . . . . . . . . . .
Liquid Rise Rate (ft/hr) . . . . . . . . . . . . . . . . . . . .
Surface Area – Weir-Length Ratio (sq ft/ft) . . . . . . . . . .

(Sludge)
Solids Loading (lb MLTSS/day/sq ft) . . . . . . . . . . . . . .
CSDT – F.C. Sludge Detention Time (hrs) . . . . . . . . . . . .
BLT – Sludge Blanket Thickness (ft) . . . . . . . . . . . . . .

PROCESS CHARACTERISTICS
lbs TSS under Aeration . . . . . . . . . . . . . . . . . . . . .
lbs TSS in Final Clar . . . . . . . . . . . . . . . . . . . . . .
lbs TSS in system . . . . . . . . . . . . . . . . . . . . . . . .

Sludge Wasted Intent. (MGD) . . . . . . . . . . . . . . . . . .
Sludge Wasted Intent. (lbs/day) . . . . . . . . . . . . . . . .

F.E. TSS (mg/l) . . . . . . . . . . . . . . . . . . . . . . . .
F.E. TSS (lbs/day) . . . . . . . . . . . . . . . . . . . . . . .

Total Sludge Wasted per day (lbs/day) . . . . . . . . . . . . .
(Intentional Wasting + Effluent Solids) . . . . . . . . . . . .

Sludge Age (days) . . . . . . . . . . . . . . . . . . . . . . .

Aeration Tank DO (mg/l) . . . . . . . . . . . . . . . . . . . .

**PLANT NAME** ______________________________ **SUPERVISOR** __________

**Location – City** ______________________________ **State** __________

**Phone No.** ____________________

**DATE OR PERIOD**
**(Daily, Weekly or Monthly Averages)** . . . . . . . . . . . . . . .

Mixed Liquor Settling & Compaction

$SSV_5$ ____________________ $SSC_5$ ____________________

$SSV_{30}$ ____________________ $SSC_{30}$ ____________________

$SSV_{60}$ ____________________ $SSC_{60}$ ____________________

$SSV_{120}$ ____________________ $SSC_{120}$ ____________________

SVI ____________________ RSC ____________________

PROCESS PERFORMANCE

Clarifier Effluent Turbidity (JTU, FTU or NTU) . . . . . . . . .
Influent TSS (mg/l) . . . . . . . . . . . . . . . . . . . . . .
Efffluent TSS (mg/l) . . . . . . . . . . . . . . . . . . . . .
% Reduction (%) . . . . . . . . . . . . . . . . . . . . . . .

Influent Total $BOD_5$ (mg/l) . . . . . . . . . . . . . . . .
Effluent Total $BOD_5$ (mg/l) . . . . . . . . . . . . . . . .
% Reduction (%) . . . . . . . . . . . . . . . . . . . . . . .

Influent Soluble $BOD_5$ (mg/l) . . . . . . . . . . . . . . .
Effluent Soluble $BOD_5$ (mg/l) . . . . . . . . . . . . . . .
% Reduction (%) . . . . . . . . . . . . . . . . . . . . . . .

Influent Total COD (mg/l) . . . . . . . . . . . . . . . . . .
Effluent Total COD (mg/l) . . . . . . . . . . . . . . . . . .
% Reduction (5) . . . . . . . . . . . . . . . . . . . . . . .

Influent Soluble COD (mg/l) . . . . . . . . . . . . . . . . .
Effluent Soluble COD (mg/l) . . . . . . . . . . . . . . . . .
% Reduction (%) . . . . . . . . . . . . . . . . . . . . . . .

Influent $NH_3$ (mg/l) . . . . . . . . . . . . . . . . . . . .
Effluent $NH_3$ (mg/l) . . . . . . . . . . . . . . . . . . . .

Influent $NO_3$ (mg/l) . . . . . . . . . . . . . . . . . . . .
Effluent $NO_3$ (mg/l) . . . . . . . . . . . . . . . . . . . .

**PLANT NAME** ______________________________ **SUPERVISOR** __________

**Location -- City** ______________________________ **State** __________

**Phone No.** ____________________

REMARKS & FLOW DIAGRAM

# ACTIVATED SLUDGE PROCESS EVALUATION

## Additional Information

**PLANT NAME** ______________________________ **SUPERVISOR** __________

**Location – City** ______________________________ **State** __________

**Phone No.** ____________________

### PRIMARY TREATMENT FACILITIES

(Rectangular or Circular) . . . . . . . . . . . . . . . . . . . . .
(Center or Peripheral Feed) . . . . . . . . . . . . . . . . . . . .
(Effluent Launder Arrangement) . . . . . . . . . . . . . . . . .
(Sludge Mech – Flows, Suction, etc) . . . . . . . . . . . . . .

No. of Tanks Available . . . . . . . . . . . . . . . . . . . . . .
Tank Dimensions . . . . . . . . . . . . . . . . . . . . . . . . . .
CSA – Surface Area/Tank (sq ft) . . . . . . . . . . . . . . . .
CVF – Volume/Tank (cu ft) . . . . . . . . . . . . . . . . . . .
CVG – Volume/Tank (gals) . . . . . . . . . . . . . . . . . . .

No. of Tanks in Service . . . . . . . . . . . . . . . . . . . . .
CSA – Total Surface Area (sq ft) . . . . . . . . . . . . . . . .
CVF – Total Volume (cu ft). . . . . . . . . . . . . . . . . . . .
CVG – Total Volume (gals) . . . . . . . . . . . . . . . . . . .

### INFLUENT TO PRIMARY PROCESS

Average Flow (MGD) . . . . . . . . . . . . . . . . . . . . . . .
$BOD_5$ (mg/l) . . . . . . . . . . . . . . . . . . . . . . . . . . .
$BOD_5$ (lb/day) . . . . . . . . . . . . . . . . . . . . . . . . .
TSS (mg/l) . . . . . . . . . . . . . . . . . . . . . . . . . . . .
TSS (lb/day) . . . . . . . . . . . . . . . . . . . . . . . . . . .

### PRIMARY CLARIFIER DETENTION TIME

@ Average Influent Flow (hrs) . . . . . . . . . . . . . . . . .

### PRIMARY CLARIFIER EFFLUENT

$BOD_5$ (mg/l) . . . . . . . . . . . . . . . . . . . . . . . . . . .
$BOD_5$ (lbs/day) . . . . . . . . . . . . . . . . . . . . . . . . .
TSS (mg/l) . . . . . . . . . . . . . . . . . . . . . . . . . . . .
TSS (lbs/day) . . . . . . . . . . . . . . . . . . . . . . . . . .

### REDUCTIONS

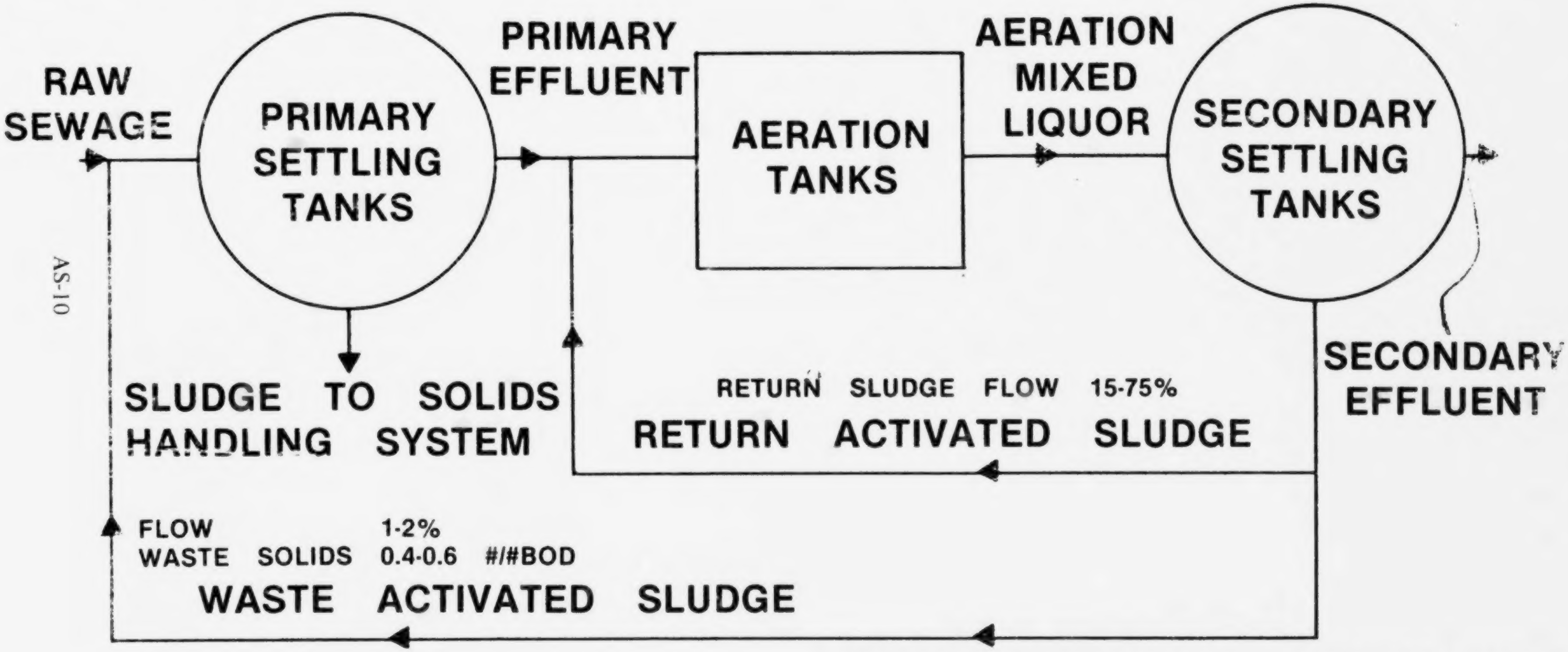
$BOD_5$ (%) . . . . . . . . . . . . . . . . . . . . . . . . . . . .
TSS (%) . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .

Does Primary Effluent differ from Secondary Influent (AFT)? What are Recycled Floc, if any?
Disposition of Primary Sludge?
Describe Sludge Handling Facilities

# CONVENTIONAL ACTIVATED SLUDGE PROCESS

DETENTION TIME 4-8 HR.
LOADING 30-40 #BOD/1,000 FT$^3$
F/M 0.2-0.5 #BOD/#MLVSS
AIR 750-1,000 FT$^3$/#BOD
SLUDGE AGE 4-6 DAYS

OVERFLOW RATE 800-1,000 GPD/FT$^2$
DETENTION TIME 1-3 HR.



RAW SEWAGE

PRIMARY SETTLING TANKS

SLUDGE TO SOLIDS HANDLING SYSTEM

PRIMARY EFFLUENT

AERATION TANKS

AERATION MIXED LIQUOR

SECONDARY SETTLING TANKS

SECONDARY EFFLUENT

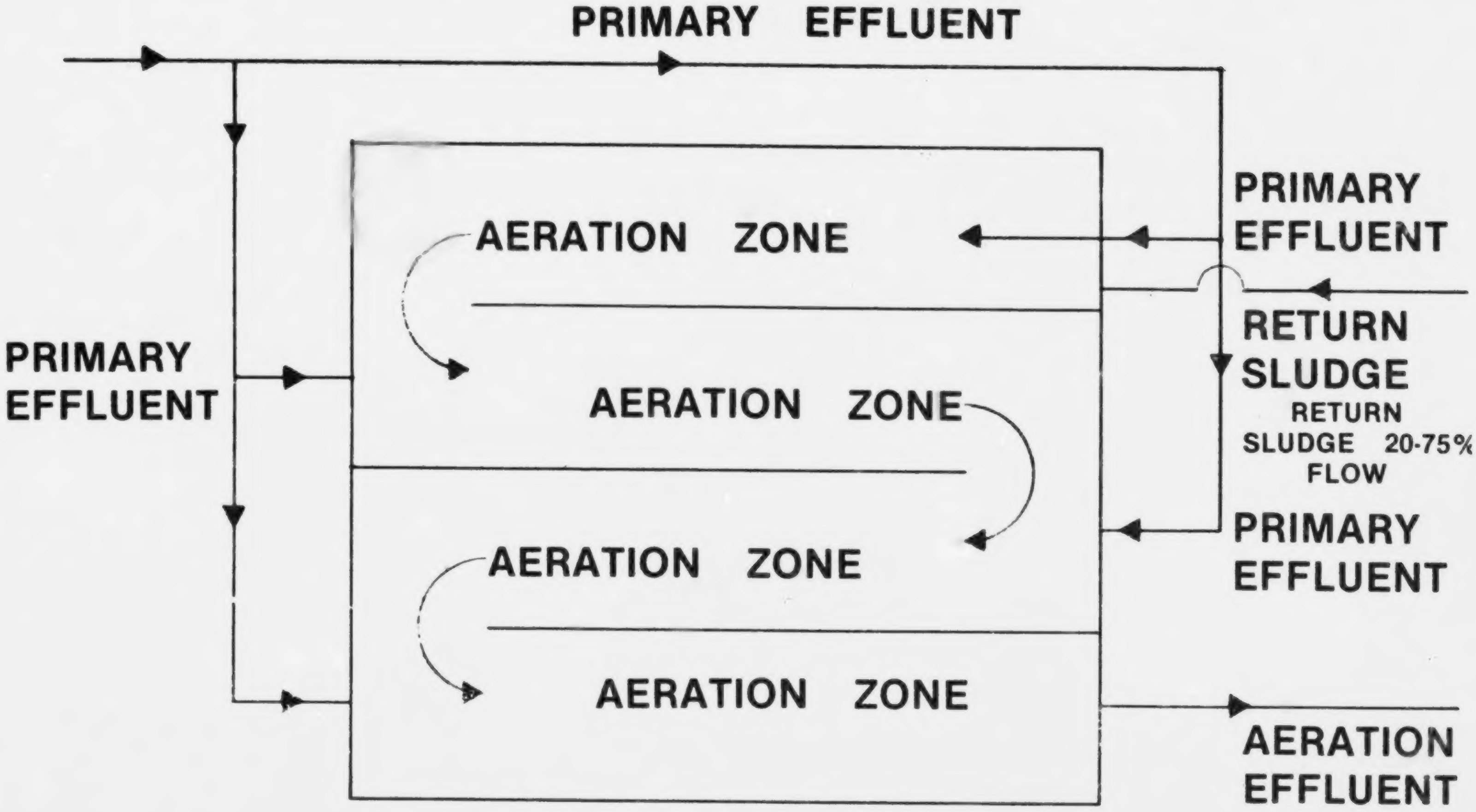
RETURN SLUDGE FLOW 15-75%

RETURN ACTIVATED SLUDGE

FLOW 1-2%
WASTE SOLIDS 0.4-0.6 #/#BOD

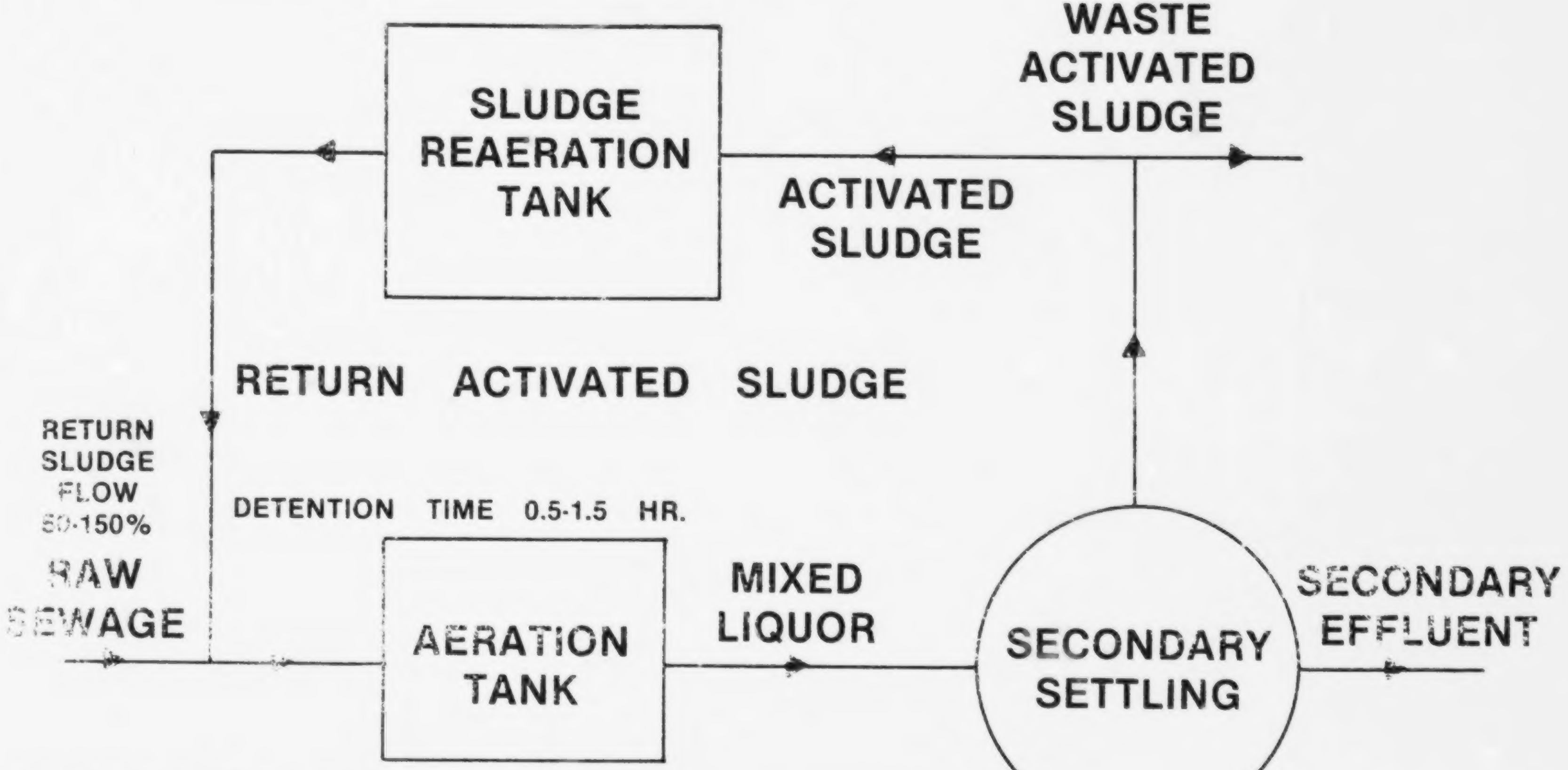
WASTE ACTIVATED SLUDGE

| | |
|---|---|
| DETENTION TIME | 3-8 HR. |
| LOADING | 40-60 #BOD/1,000 $FT^3$ |
| F/M | 0.2-0.5 #BOD/#MLVSS |
| AIR FLOW | 500-700 $FT^3$/#BOD |


PRIMARY EFFLUENT
PRIMARY EFFLUENT
AERATION ZONE
AERATION ZONE
AERATION ZONE
AERATION ZONE
PRIMARY EFFLUENT
RETURN SLUDGE
RETURN SLUDGE 20-75% FLOW
PRIMARY EFFLUENT
AERATION EFFLUENT

# STEP AERATION ACTIVATED SLUDGE PROCESS

| | |
|---|---|
| DETENTION TIME | 4-8 HR. |
| LOADING | 35-70 #BOD/1,000 $FT^3$ (COMBINED VOLUME) |
| F/M | 0.2-0.5 #BOD/#MLVSS (CONTACT TANK) |
| AIR FLOW | 750-1,500 $FT^3$/#BOD |



SLUDGE REAERATION TANK

WASTE ACTIVATED SLUDGE

ACTIVATED SLUDGE

RETURN ACTIVATED SLUDGE

RETURN SLUDGE FLOW 50-150%

DETENTION TIME 0.5-1.5 HR.

RAW SEWAGE

AERATION TANK

MIXED LIQUOR

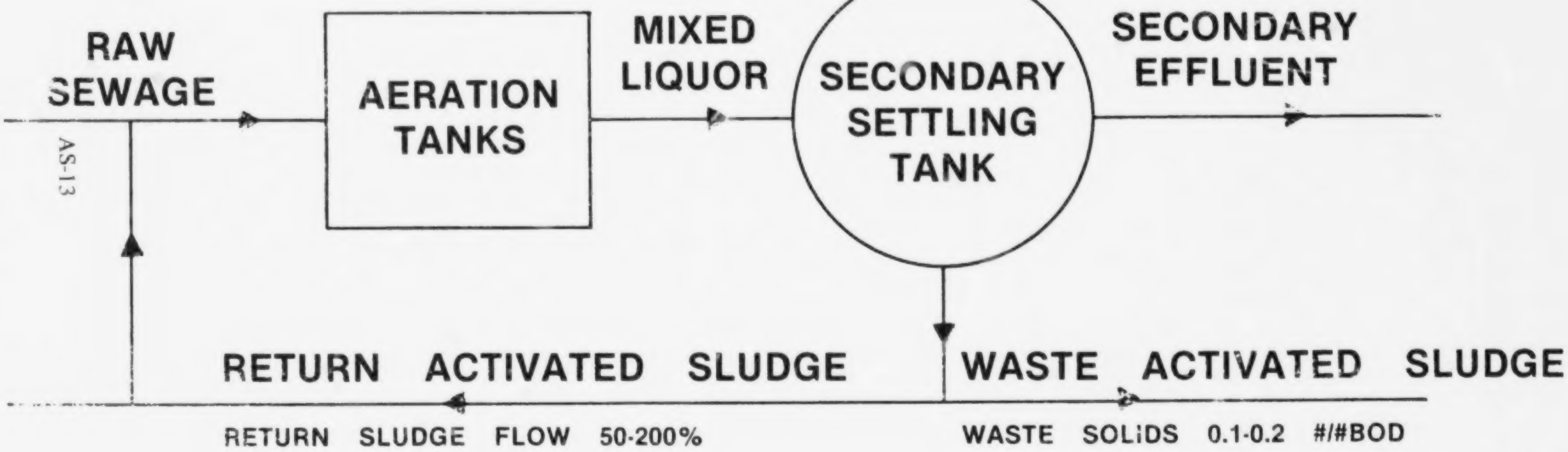
SECONDARY SETTLING

SECONDARY EFFLUENT

# CONTACT STABILIZATION PROCESS

DETENTION TIME 16-24 HR.
LOADING 10-15 #BOD/1,000 $FT^3$
F/M 0.01-0.08 #BOD/#MLVSS
AIR FLOW 2,000-2,500 $FT^2$/#BOD

OVERFLOW RATE 300-600 GPD/$FT^2$


RAW SEWAGE
AERATION TANKS
MIXED LIQUOR
SECONDARY SETTLING TANK
SECONDARY EFFLUENT
RETURN ACTIVATED SLUDGE
WASTE ACTIVATED SLUDGE
RETURN SLUDGE FLOW 50-200%
WASTE SOLIDS 0.1-0.2 #/#BOD

# EXTENDED AERATION PROCESS

## SUPPLEMENTAL INFORMATION ON CONTROL CONCEPTS

### For Students' Use and Reference

A. Food to Microorganism Ratio (F/M)

1. Defined as the pound of BOD removal per day per pound of mixed liquor suspended solids in the aeration basin. Can also define in terms of other analyses such as COD, TOC, TOD, MLVSS, etc., but numbers will be different depending on the analyses used for process control.

2. Advantages of the system of control is that it attempts to balance the incoming food load to the mass of biological solids in the aeration system. Control is achieved by *wasting* activated sludge. Increased wasting increases the F/M. Decreased wasting decreases the F/M.

3. Disadvantages are the need to perform complex time-consuming analyses to calculate the F/M. Does not consider solids in the clarifier. F/M then becomes more a long-range control strategy to maintain a proper quantity of solids in the system. Works best when coupled with another control strategy, such as MCRT.

4. The F/M number used for process control must be optimized for each process plant individually. There is no universal number which applies to all plants although most operate best in the 0.2 – 0.5 lb BOD removed per lb MLSS per day. The F/M for a particular plant must be determined experimentally by trying a series of F/M operating points and then selecting that F/M which gives the best effluent quality.

5. When using F/M control it is best to base control change decisions on a 5- or 7-day moving average rather than on the day-to-day values.

B. Mean Cell Residence Time (MCRT)

1. Defined as the time in days that an average cell remains in the aeration basin. Calculated by dividing the pounds of mixed liquor solids by the pounds of solids wasted per day (waste activated sludge plus effluent suspended solids).

2. Advantages are that it requires only single laboratory measurement for suspended solids and is very easy to implement.

3. Disadvantages include failure to consider the organic load on the system and the solids in the final clarifier. Most effective when used in conjunction with the F/M for process control.

4. The MCRT chosen for a given plant must be determined experimentally. The MCRT number used is the value which produces the best effluent quality. Most conventional activated sludge processes operate with an MCRT of 5 – 8 days: extended aeration MCRT may be as long as 15 – 30 days.

5. As with F/M, control decisions should be based on the 5- or 7-day moving average rather than on instantaneous day-to-day measurements.

C. Sludge Retention Time (SRT)

1. Defined as the total solids in the system (aeration basin plus final clarifier) divided by the solids wasted per day (waste activated sludge plus effluent solids).

2. Advantages and disadvantages are very similar to those cited for the MCRT strategy.

3. Added disadvantage is that it considers the solids in the final clarifier but does not consider how the suspended solids are distributed between the clarifier and the aeration basin.

4. Proper SRT value is determined experimentally.

5. Control decisions should be based on 5- or 7-day moving averages rather than instantaneous day-to-day values.

D. Sludge Age (SA)

1. Sludge age is defined as the pounds of suspended solids in the aeration system divided by the pounds of suspended solids in the primary effluent per day.

2. Sludge Age is an empirical control parameter developed by Gould as a control parameter for his treatment plant. There is no theoretical basis to support the validity of this control concept; hence it will not be discussed further.

E. Constant Mixed Liquor Suspended Solids (MLSS)

1. With this strategy, a MLSS concentration which produces a good effluent quality is determined and process control is achieved by holding the MLSS constant. Control is achieved by varying the waste activated sludge rate.

2. Advantage of the system is simplicity. One analysis is made at the same time each day and the quantity of sludge to be wasted is calculated and the waste rate adjusted accordingly.

3. Disadvantages to this strategy are many. It does not consider variations in organic or volumetric load. It does not consider solids in the clarifier. It requires that influent conditions be fairly constant from day to day and that samples be taken from the same point and at the same time each day. Many operators consider this to be among the most unreliable methods of process control.

4. MLSS concentration is controlled by varying the waste rate.

F. Respiration Rate (RR) or Oxygen Uptake Rate

   1. The RR is defined as the mg/l/min of oxygen consumed per gram of MLSS. RR must be determined for several different sludge-raw wastewater effluent mixtures as indicated below:

      a. Mixed liquor sample as it leaves the aeration basin
      b. Return activated sludge diluted with final effluent
      c. Return activated sludge diluted with primary effluent or raw wastewater

   2. There are many advantages to the RR as a control parameter:

      a. It gives a rapid measure of influent organic load and its biodegradability

      b. It indicates the presence of toxic or inhibitory wastes

      c. It indicates the condition of the return sludge

      d. It indicates the degree of "stability" of the final effluent and the MLSS entering the final clarifier

      e. It permits calculation of oxygen demand rates at various points in the aeration basin and hence closer control of air application rates

      f. It provides information to control both return and waste rates

   3. Disadvantages of the RR as a control strategy include:

      a. Several samples must be collected, analyzed, and evaluated

      b. The test procedure requires sophisticated and relatively time-consuming laboratory procedures

      c. A great deal of experience is required to effectively interpret the results of the tests and to apply them

4. The proper RR values for the various points in a given treatment plant must be determined experimentally. The RR for mixed liquor leaving the aeration basin is normally in the range 12 - 16 mg/l/min/gm MLSS. This range is normally associated with good BOD removal and a sludge which settles well.

5. RR provides information which permits control of both waste rate and return rate from the final clarifier. Some of the information which can be obtained from RR data includes:

   a. Increasing RR at the effluent of the aeration basin could indicate increasing organic load, increasing hydrualic load and lower aeration basin detention time, or decreasing MLSS (increasing F/M). By combining this data with the RR data on the primary effluent and flow rate appropriate decision to increase or decrease return and/or waste rates could be made.

   b. Decreasing RR at the effluent of the aeration basin could indicate decreasing organic load, decreasing hydraulic load, or increasing MLSS (decreasing F/M). Again, looking at this RR and influent data, decisions on changes required in return or waste rates can be made.

6. Additional information of the use of RR for activated sludge process control can be found in the EPA slide tape XT-43 "Dissolved Oxygen in Activated Sludge" by F.J. Ludzack available on loan from EPA's National Training Center in Cincinnati, Ohio.

G. Sludge Quality

1. Sludge quality was discussed previously and the characteristics of good and bad sludge quality were reviewed. Key point to keep in mind is that all process control strategies discussed above have a single objective: achieve and maintain good sludge quality which produces a highly purified effluent, settles well, and concentrates in the final clarifier.

2. Sludge quality control concepts were pioneered by Mallory in the thirties and have been significantly advanced and improved by West. The pamphlet series that was included in your handout materials is an indepth discussion of sludge quality control as practiced by Mr. West. Trainees should read these pamphlets carefully.

3. Sludge quality control is based on the concept that the sludge settling characteristics will change as activated sludge process conditions change. A change in influent organic load, influent hydraulic load, sludge retention time in the aeration basin, MLSS concentration, return sludge flow rate, etc, will affect the settling and concentration characteristics of the sludge. The sludge settling rate and concentration rate are very sensitive indicators of changes in process condition and can be used to indicate process control actions needed to maintain good system performance. Combining the data from sludge settling and concentration measurements with the data from F/M and MCRT control provides a very powerful tool to control the activated sludge process.

4. An advantage to sludge quality control is the simplicity of the test procedures. Settling rates are measured in a settleometer and concentrations of MLSS and return sludge are measured with the centrifuge. The complete testing series can be completed in about one hour. This permits the operator to do his tests more frequently and obtain better and more consistent control of the process. The test procedures are discussed in the West pamphlet series in Part II.

## ACTIVATED SLUDGE

### Additional Information for Troubleshooting Problems – Subdivision 3

Problem 1

a. F/M = 0.6
b. Settling: 5 min 950
    30 min 750
    60 min 580
c. Q = 40 MGD
d. MLSS = 1,200 mg/l
e. RAS = 4,200 mg/l
f. Reaeration is possible
g. Return rate = 40%

Problem 2

a. MCRT = 14 days
b. F/M = 0.13
c. MLSS = 4,200 mg/l
d. RAS = 12,600 mg/l
e. Settling: 5 min 630
    30 min 360
    60 min 330
f. There has been no sludge waste in 7 days

Problem 3

a. MCRT = 15 days
b. F/M = 0.07
c. Q = 0.3 MGD
d. RAS = 3,480 mg/l
e. MLSS = 2,400 mg/l
f. % RAS = 160%
g. Settling: 5 min 405
    30 min 140
    60 min 115

## ACTIVATED SLUDGE – SUBDIVISION 5

### Hamsborough Troubleshooting Problem – Part 1

You, as newly appointed District Engineer for your State's Department of Environmental Protection, are preparing to inspect the Municipal Wastewater treatment plant at Hamsborough. As your first step, you search through your predecessor's files but can find only limited information on the facility; there has been no previous inspection of the Hamsborough facility. However, by digging further into the files you do find some information on the community and the plant.

Hamsborough is a small suburban community with a population of about 15,000 with some light industry, mostly trucking and warehousing operations. There are two significant industrial dischargers to the system, a small printing plant which specializes in novelty printing and a meat processing and packaging plant.

A schematic flow diagram of the Hamsborough Wastewater Plant is shown on page AS-22. The major plant units are: a primary clarifier, followed by a single stage high rate trickling filter, followed by a complete mixing activated sludge plant with final clarifiers, and a chlorination system for disinfecting the final effluent. Two anaerobic digesters are used in series to handle all the sludge removed from the treatment facilities.

The original treatment plant consisted only of the primary clarifier and a trickling filter. Due to high organic loads from the meat packing plant, the design hydraulic loading is 2.1 MGD but the design population equivalent is 45,000. In the last few years the packing plant has become mainly a meat processing operation and the wastes received from the plant carry much less organic material than was previously received. The meat processing plant has its own primary clarifier which removes some of the solids and grease before the sewage enters the treatment facility.

At the treatment site the primary treated meat packing wastes combine with the raw sewage from Hamsborough and then enter the primary treatment units. The primary clarifier is a rectangular tank approximately ninety feet long and forty feet wide. Primary sludge is scraped along the bottom of the tank to the head end where it is collected into a sludge hopper. Sludge is then pumped to the primary digester. Waste activated sludge, which includes trickling filter solids since there is no intermediate clarifier, also enters the primary clarifier and is pumped with the primary sludge to the primary digester. Supernatant from the digesters and from the drying beds is returned to the primary clarifier. Digested sludge is pumped out to the drying beds.

Effluent from the primary tank is pumped to a trickling filter. A portion of the trickling filter effluent is returned back to the wet well and is recycled through the filter. The flow pumped to the trickling filter is held at a constant rate by regulating the amount of filter effluent entering the wet well.

The trickling filter effluent not recirculated to the wet well enters the aeration system. There are essentially two identical activated sludge treatment units, and the flow is split between the east unit and the west unit. The aeration system is a package process which is essentially a high-rate complete mixing activated sludge rapid-bloc process. The aeration tank and final clarifiers have a common wall. Activated sludge enters the final clarifiers through ports between the clarifiers and aeration tanks. There are three airlift pumps for each unit to waste excess sludge. The settled activated sludge in the clarifiers is returned through a chimney type opening to the aeration basin. The driving force for the return sludge is primarily due to the upward lift action of the air diffusers in the adjacent aeration tanks — a principle much like that of an airlift pump.

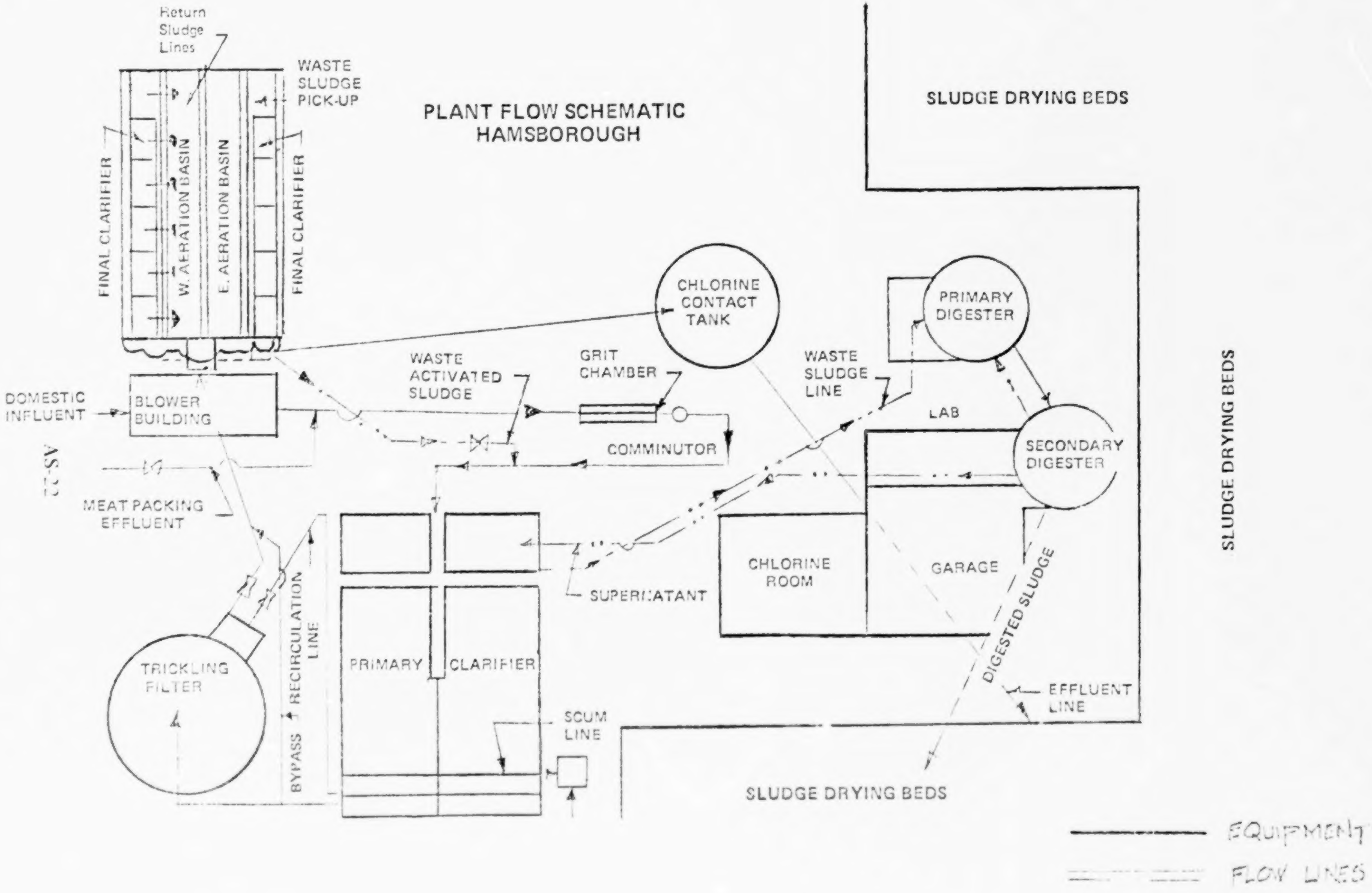
Clarified sewage passes over the weirs of the clarifiers to the effluent troughs and into a chlorine contact basin. The chlorine contact basin is a converted primary clarifier. Chlorine is introduced into the inlet pipe just prior to the introduction to the clarifier. The solids scraping mechanism of the clarifier is still intact. Disinfected sewage overflows the weirs, enters the discharge pipe and is discharged into Hamm Creek.

Performance data submitted to the state agency on monthly reports for the previous six months are summarized below:

| Month | Flow, mgd |  |  | $BOD_5$ | TSS | $Cl_2$ |
|---|---|---|---|---|---|---|
|  | Avg. | Max. | Min. | mg/l | mg/l | mg/l |
| September | 2.12 | 2.55 | 1.83 | – | 13 | 0.4 |
| October | 2.14 | 2.52 | 1.84 | 14 | 19 | 0.5 |
| December | 1.59 | 1.87 | 1.23 | 8 | 18 | 0.5 |
| January | 1.80 | 2.25 | 1.30 | 7 | 20 | 0.5 |
| February | 1.70 | 1.83 | 1.52 | 7 | 14 | 0.5 |
| March | 1.63 | 1.74 | 1.48 | 12 | 19 | 0.5 |

Briefly review and answer the four questions that appear on the answer sheet in your Notebook under Part I.

# PLANT FLOW SCHEMATIC
# HAMSBOROUGH


Return Sludge Lines
WASTE SLUDGE PICK-UP
FINAL CLARIFIER
W. AERATION BASIN
E. AERATION BASIN
FINAL CLARIFIER
DOMESTIC INFLUENT
BLOWER BUILDING
MEAT PACKING EFFLUENT
WASTE ACTIVATED SLUDGE
GRIT CHAMBER
COMMINUTOR
CHLORINE CONTACT TANK
WASTE SLUDGE LINE
PRIMARY DIGESTER
LAB
SECONDARY DIGESTER
SLUDGE DRYING BEDS
SLUDGE DRYING BEDS
CHLORINE ROOM
GARAGE
DIGESTED SLUDGE
EFFLUENT LINE
SUPERNATANT
TRICKLING FILTER
RECIRCULATION LINE
BYPASS
PRIMARY CLARIFIER
SCUM LINE
SLUDGE DRYING BEDS
EQUIPMENT
FLOW LINES

## ACTIVATED SLUDGE — SUBDIVISION 5

### Hamsborough Troubleshooting Problem — Answer Sheet

**Student Group** ____________________

### Part I

1. Describe the steps you would take in approaching the inspection of the Hamsborough Plant.

2. Name the locations within the plant where you would have sample collected.

3. What data would you seek through sampling?

4. What are your preliminary judgments about the plant prior to your visit?

### Part II

The instructor will assume the role of plant operator, and will answer any questions you may have.

5. Based on all of the observations made, indicate what your next steps would be in troubleshooting this plant. In proceeding through this portion of the exercise you are aware that the current NPDES permit for the facility requires an effluent which meets a 30 mg/l BOD and 30 mg/l TSS standard. In June, the State will revise the permit and the facility will be required to meet a 20/20 standard.

6. What actions will you take or recommend for this plant to meet the new, more stringent standard?

7. Which data would you collect and analyze before you make your final recommendation?

8. Prioritize alternatives and best solutions.

## ACTIVATED SLUDGE – SUBDIVISION 6

### City of Pullman, Sewage Treatment Plant
### Department of Public Works

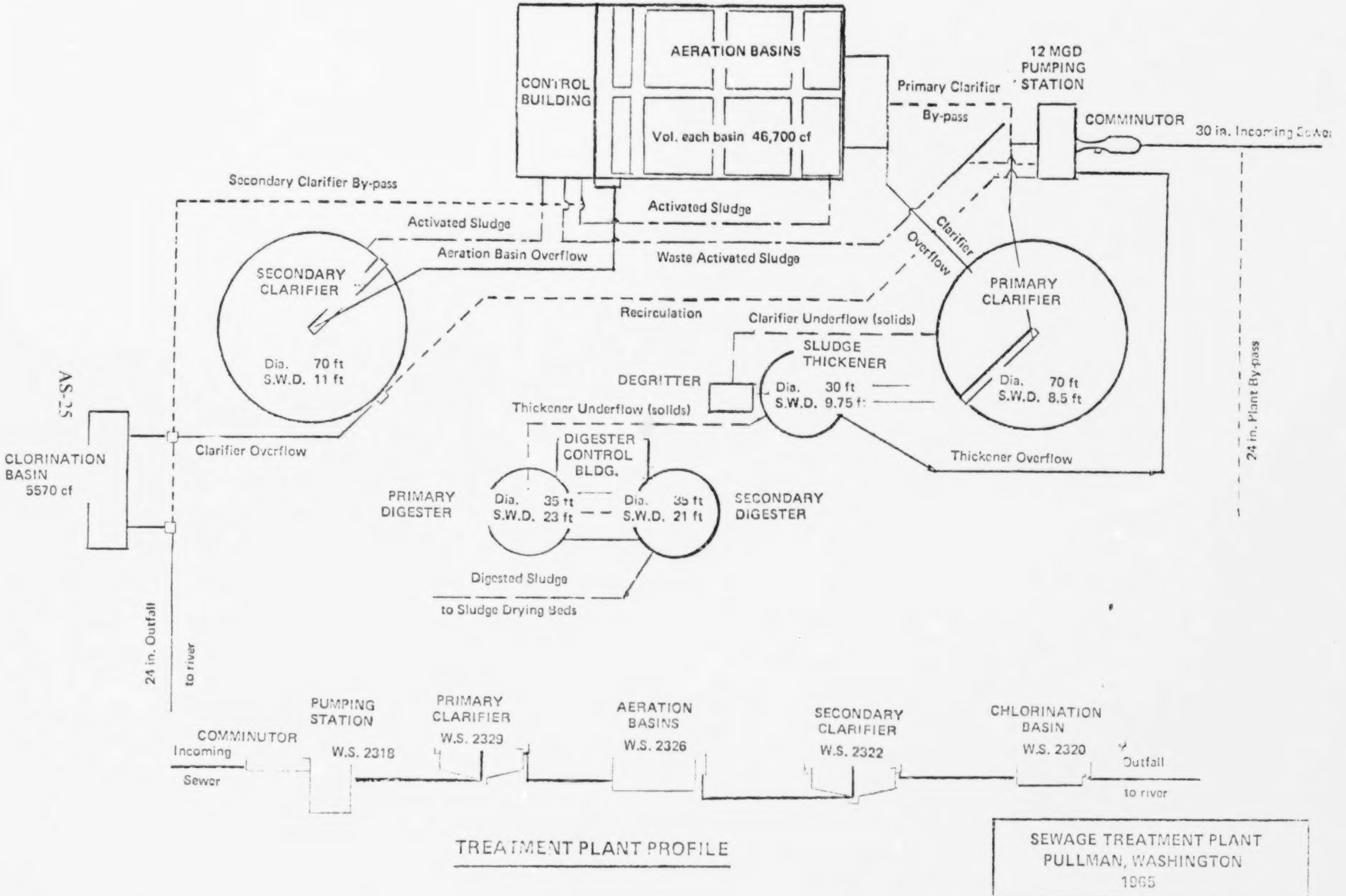
This City of Pullman facility is operated by the Department of Public Works and treats the sewage from both the community and the Washington State University Campus. WSU contributes financially to the maintenance and operation of the plant.

The original plant was completed in 1949 at a cost of approximately $300,000. This plant was a bio-filtration type treatment plant.

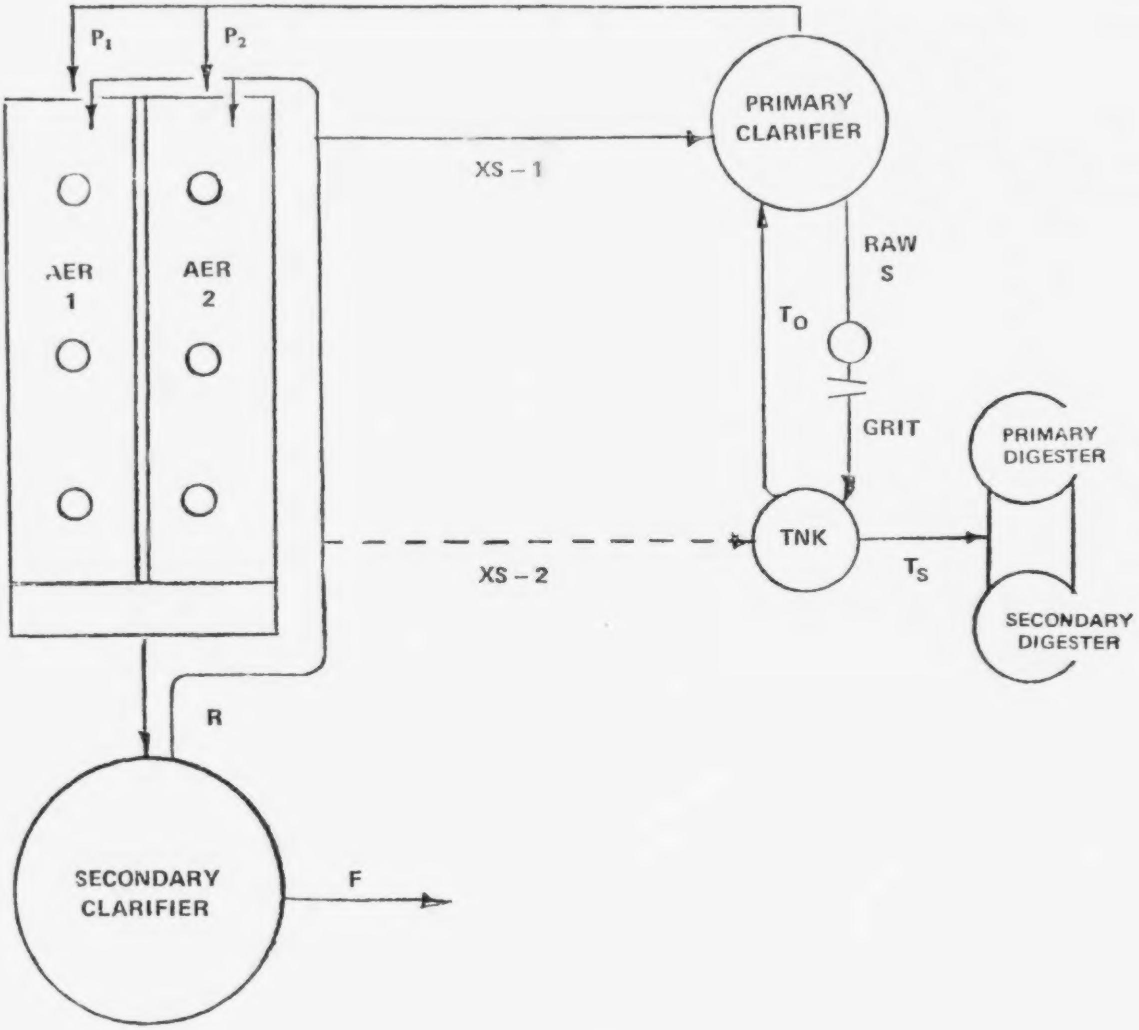
Due to the increased use of water by the population, it became necessary to increase the capacity of the plant. To accomplish this, the plant was remodeled in 1965. At that time it was changed to an activated sludge type plant to more effectively treat both the low quantity of sewage received during the summer months and the high quantities received during the winter months with the return of the students to WSU. The remodeling cost was approximately $500,000.

Operational History

1. Plant is at maximum hydraulic capacity during wet weather in excess of 4.0 MGD
2. Student population from WSU affects plant loading
3. It is hard to stabilize the plant operation during and after student vacations, particularly Thanksgiving and Christmas
4. The plant has a weak sewage averaging between 80 and 120 BOD
5. Characteristically the plant has carried a low MLSS
6. Aeration tanks have three sparge-turbine type aerators in each tank
7. The aerators have a hydrogen sulfide odor when the DO drops near 0
8. No digester supernatant is returned to the system, all of it is hauled and disposed-of on land
9. Waste sludge is typically wasted back to the primary clarifiers


CONTROL BUILDING
AERATION BASINS
Vol. each basin 46,700 cf
12 MGD PUMPING STATION
COMMINUTOR
30 in. Incoming Sewer
Primary Clarifier By-pass
Clarifier Overflow
Secondary Clarifier By-pass
Activated Sludge
Activated Sludge
Aeration Basin Overflow
Waste Activated Sludge
SECONDARY CLARIFIER
Dia. 70 ft
S.W.D. 11 ft
Recirculation
Clarifier Underflow (solids)
PRIMARY CLARIFIER
Dia. 70 ft
S.W.D. 8.5 ft
SLUDGE THICKENER
Dia. 30 ft
S.W.D. 9.75 ft
DEGRITTER
Thickener Underflow (solids)
Thickener Overflow
24 in. Plant By-pass
CLORINATION BASIN
5570 cf
Clarifier Overflow
DIGESTER CONTROL BLDG.
PRIMARY DIGESTER
Dia. 35 ft
S.W.D. 23 ft
Dia. 35 ft
S.W.D. 21 ft
SECONDARY DIGESTER
Digested Sludge
to Sludge Drying Beds
24 in. Outfall
to river
Incoming
Sewer
COMMINUTOR
PUMPING STATION
W.S. 2318
PRIMARY CLARIFIER
W.S. 2329
AERATION BASINS
W.S. 2326
SECONDARY CLARIFIER
W.S. 2322
CHLORINATION BASIN
W.S. 2320
Outfall
to river
TREATMENT PLANT PROFILE

SEWAGE TREATMENT PLANT
PULLMAN, WASHINGTON
1965


P1
P2
PRIMARY CLARIFIER
XS – 1
AER 1
AER 2
RAW S
To
GRIT
PRIMARY DIGESTER
TNK
XS – 2
Ts
SECONDARY DIGESTER
R
SECONDARY CLARIFIER
F

SIMPLIFIED FLOW PATTERN,
PULLMAN TREATMENT PLANT

## PULLMAN, WASHINGTON – FACTS ABOUT THE PLANT

**Design Flow:**

| | |
|---|---|
| Minimum Daily Flow | 2.80 Million Gallons per day |
| Average Daily Flow | 4.00 Million Gallons per day |
| Maximum Daily Flow | 6.50 Million Gallons per day |
| Maximum Hydraulic Flow | 12.00 Million Gallons per day |

**Strength of Sewage:**

| | Suspended Solids | BOD |
|---|---|---|
| Minimum | 140 ppm | 120 ppm |
| Average | 225 ppm | 210 ppm |
| Maximum | 270 ppm | 250 ppm |

**Pump Station:**

Five Raw Sewage Pumps
2 rated 1,000 gpm @ 13′ of head each
3 rated 2,100 gpm @ 13′ of head each
Volume, wet pit at overflow: 8,950 gallons

**Primary Clarifier:**

Diameter: 70′
Side wall depth: 8.5′ Volume: 246,000 gallons

**Aeration Basins:**

Two Basins: Volume of each: 350,000 gallons
Blower Capacity: 3 blowers, each @ 600 cfm
Activated Sludge Pumps: 2 pumps, each @ 1,600 gpm @ 35′ of head

**Secondary Clarifier:**

Diameter: 70′
Side wall depth: 11′

**Chlorine Retention Basin:**

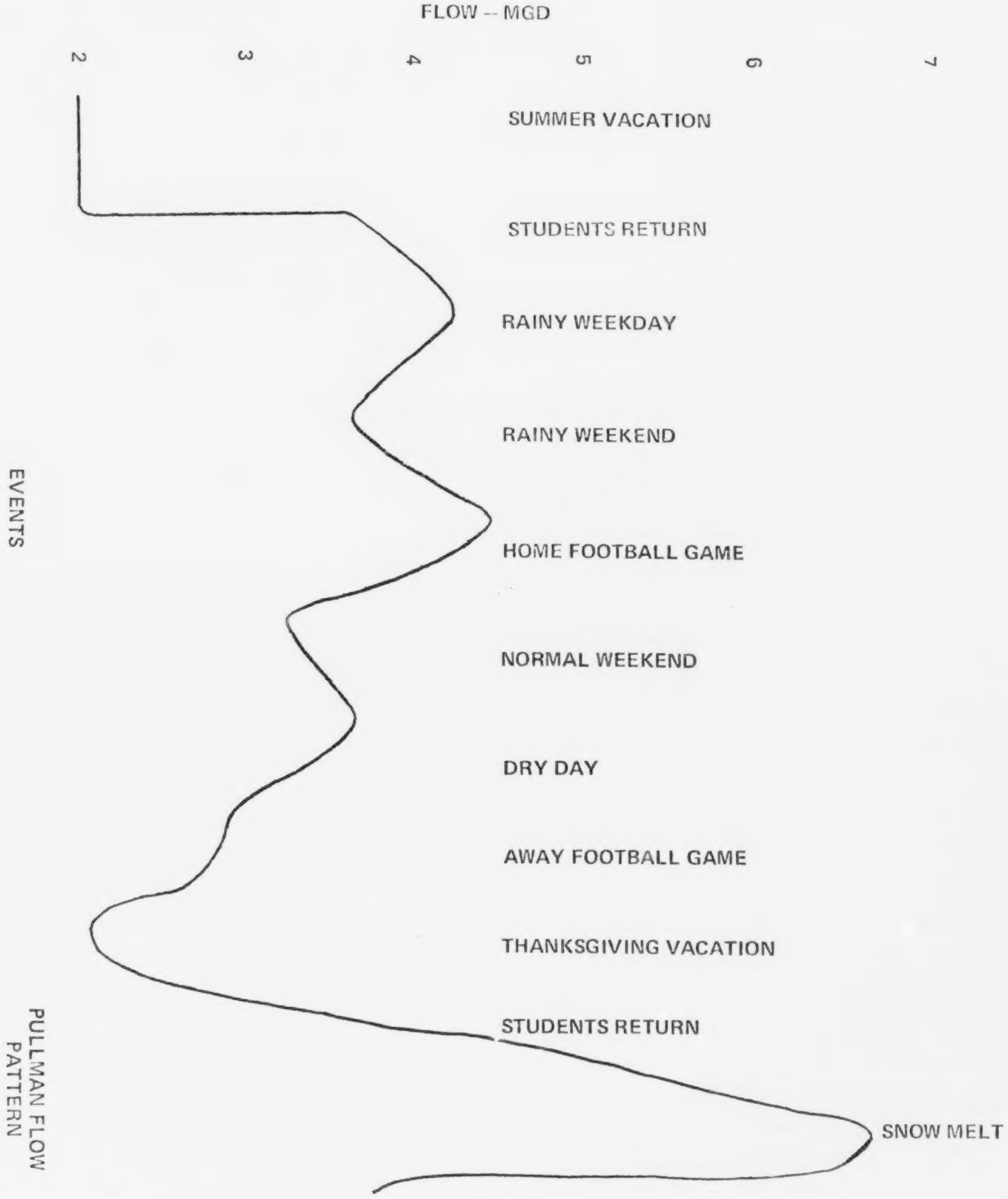
1 Basin Retention time: 20 min. minimum

**Sludge Thickener:**

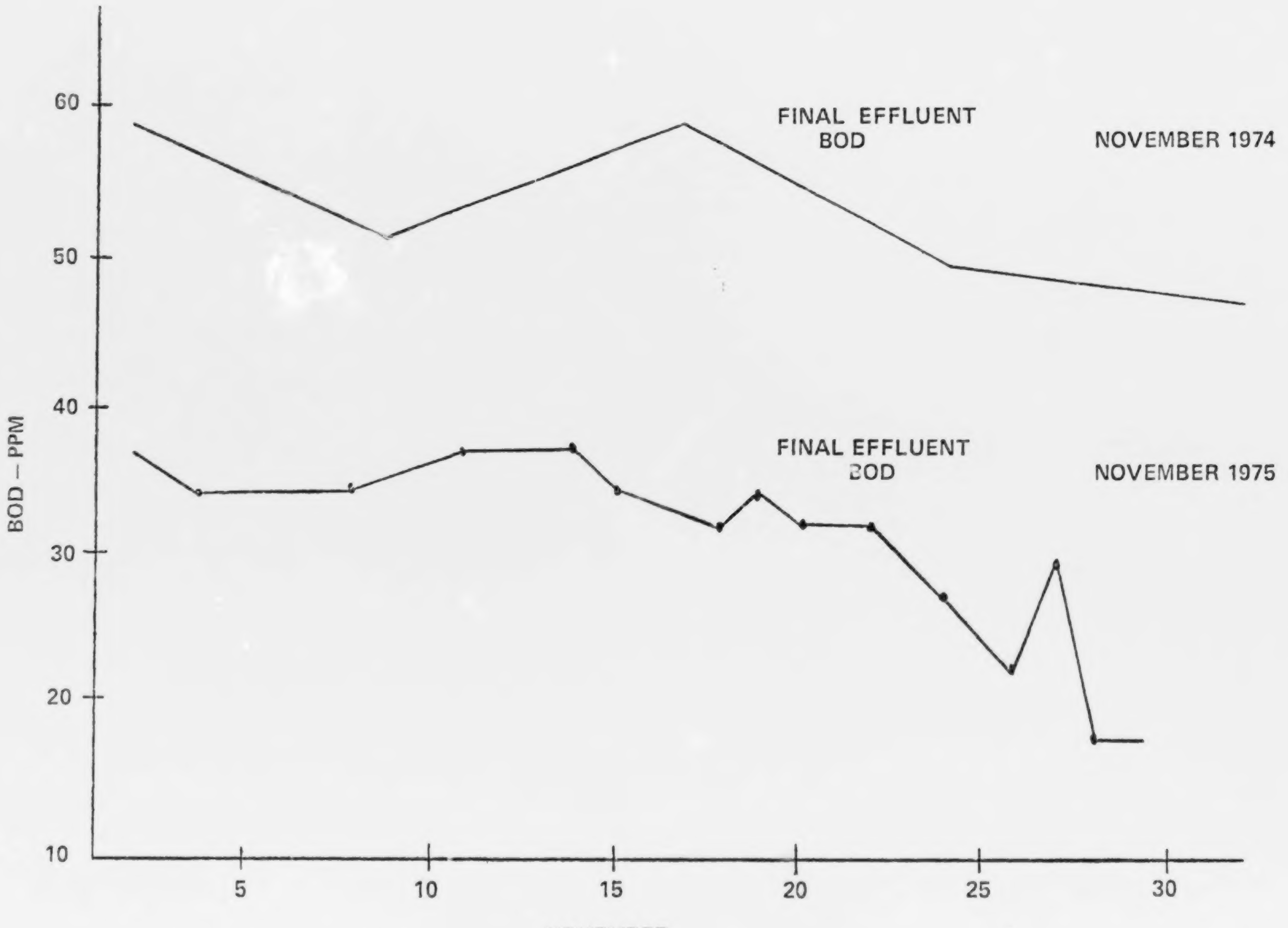
Diameter: 70′
Side wall depth: 10′ Volume: 53,000 gallons

**Slude Digesters:**

| | | | | |
|---|---|---|---|---|
| Primary: | Diameter: | 35′ | Volume: | 176,200 gallons |
| | Side wall depth: | 23′ | | |
| Secondary: | Diameter: | 35′ | Volume: | 161,200 gallons |
| | Side wall depth: | 21′ | | |
| | | | Total Volume: | 337,400 gallons |



PULLMAN FLOW PATTERN



PULLMAN – BOD REMOVAL

## ACTIVATED SLUDGE – SUBDIVISION 6

### Pullman Troubleshooting Problem – Answer Sheet

**Student Group** ______________

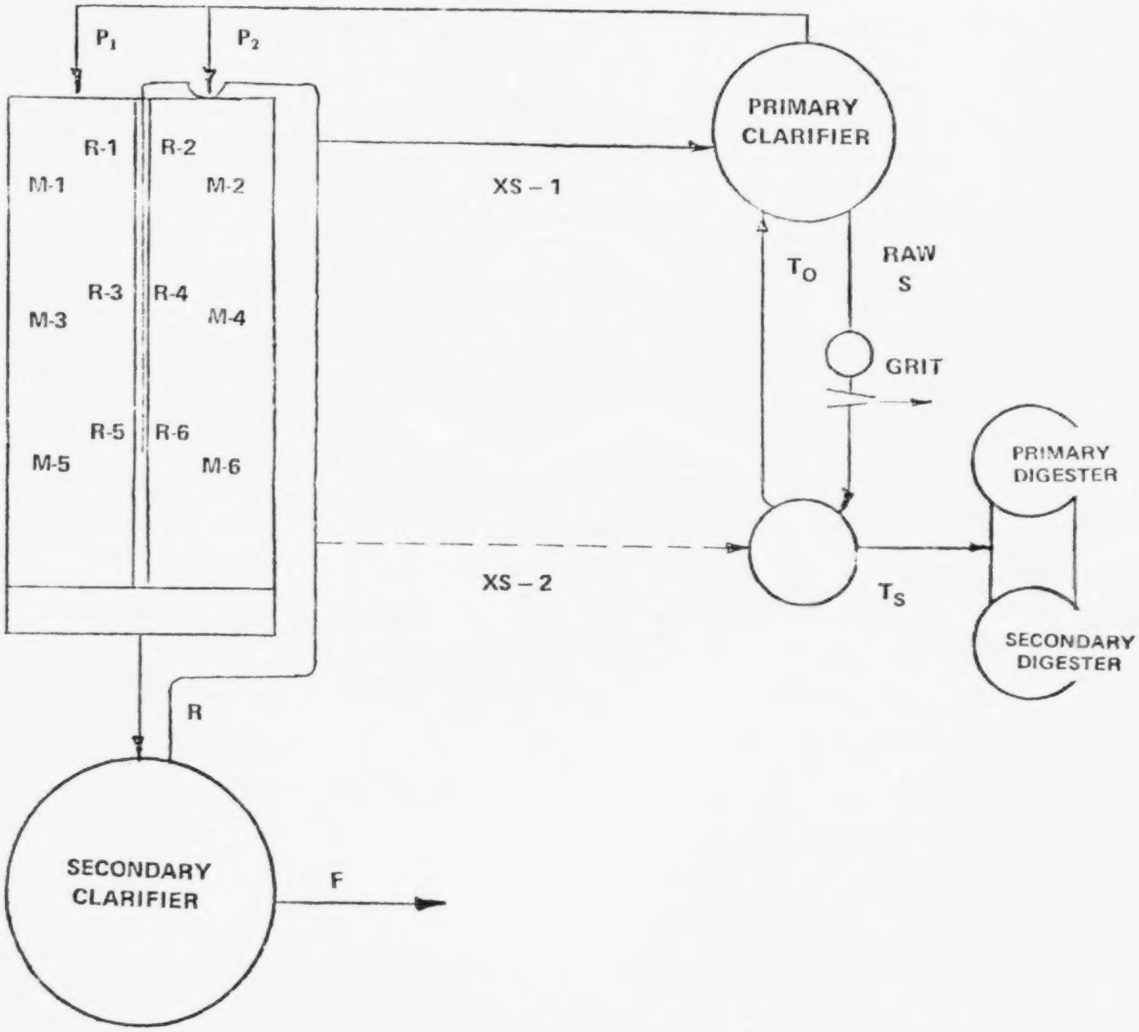
1. Briefly describe and define the problem that existed at Pullman in 1974.

2. Using the Process of Troubleshooting, describe
   a. The data you would need
   b. The analysis you would make

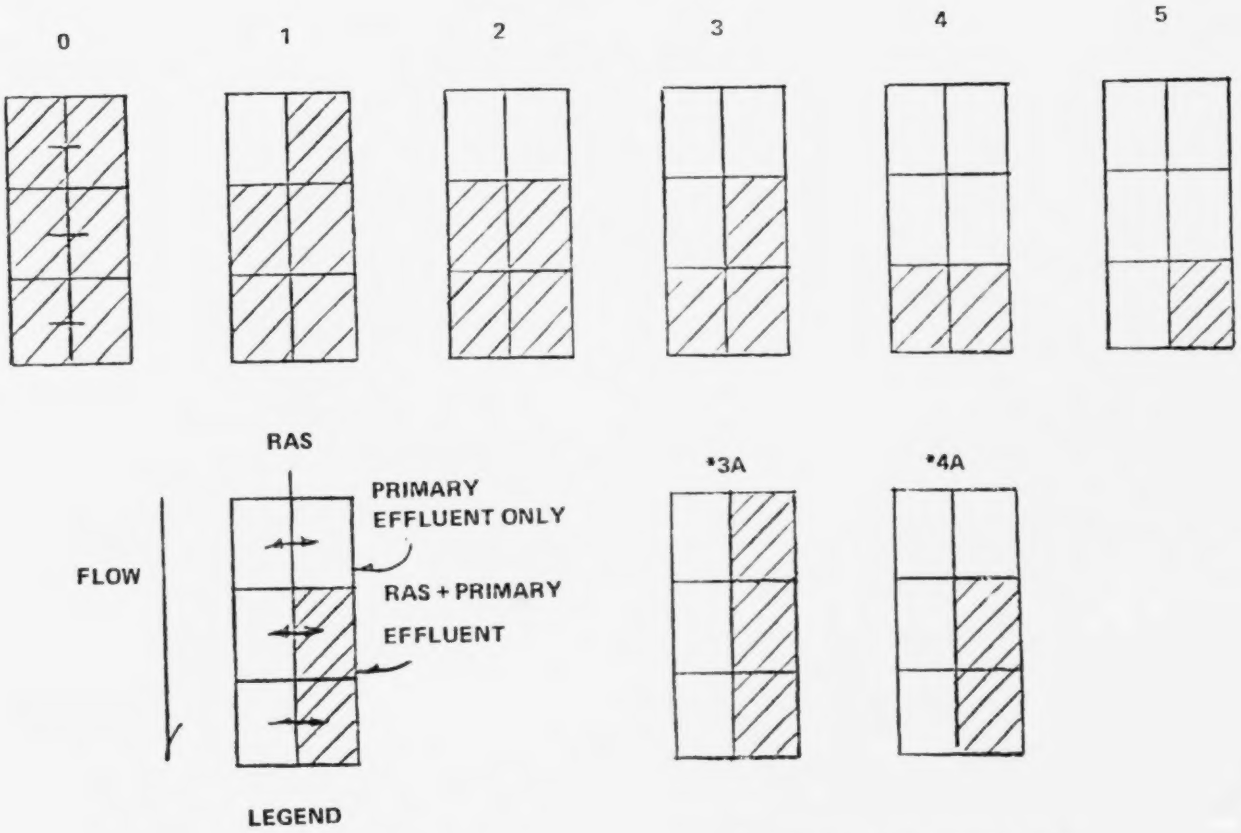
3. What process changes would you recommend to cope with the fluctuating load? What other changes?

4. What process control strategy would you use to control the activated sludge process? How would you do it?

## PULLMAN – MODIFIED RETURN ACTIVATED SLUDGE


P₁
P₂
R-1
R-2
M-1
M-2
R-3
R-4
M-3
M-4
R-5
R-6
M-5
M-6
XS – 1
XS – 2
PRIMARY CLARIFIER
T$_O$
RAW S
GRIT
PRIMARY DIGESTER
SECONDARY DIGESTER
T$_S$
R
SECONDARY CLARIFIER
F

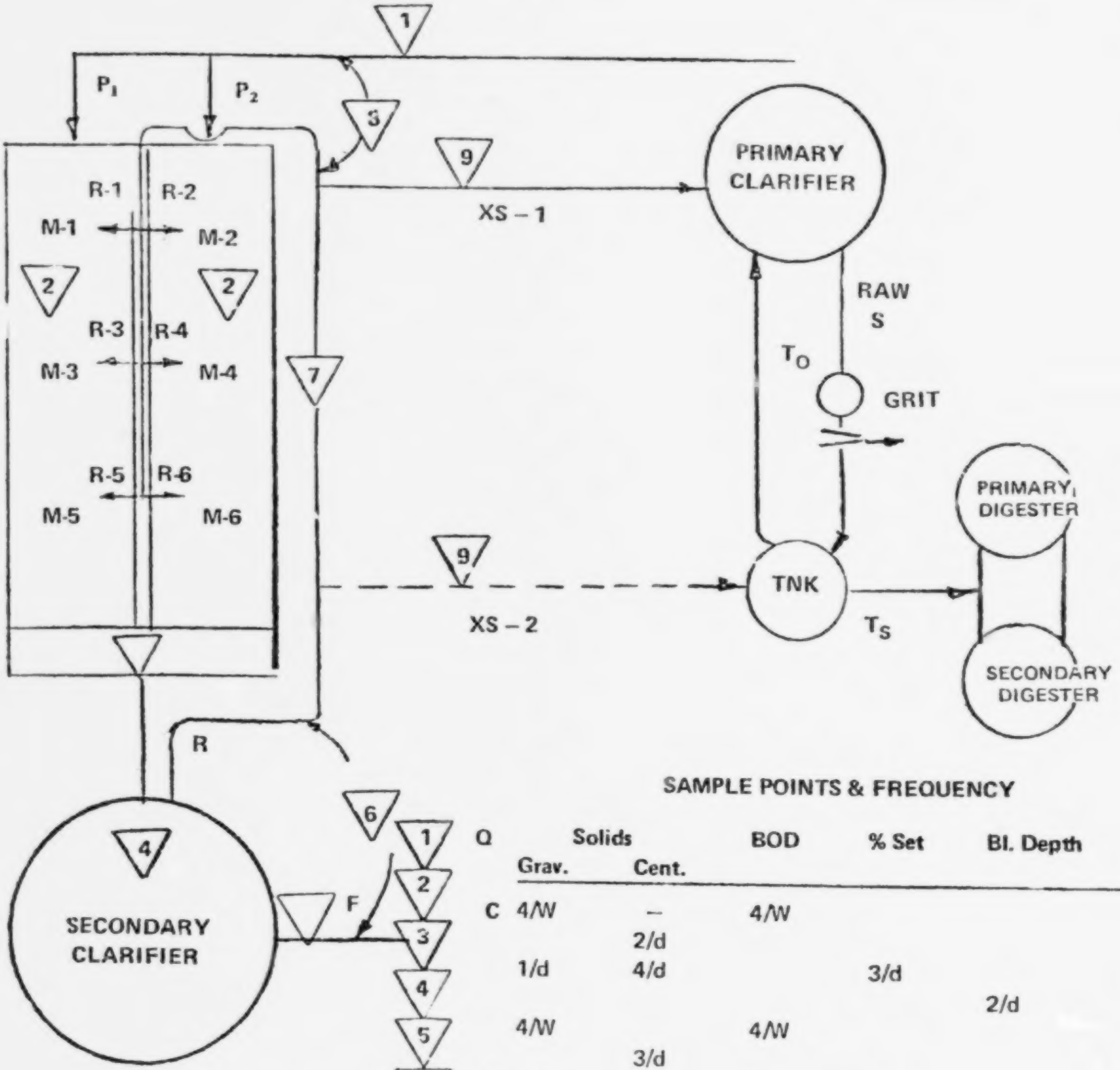
| | |
|---|---|
| P-n | Primary Effluent |
| M-n | Mixed Liquor |
| R-n | Return Sludge |
| F | Final Effluent |
| XS-n | Waste Sludge |
| $T_S$ | Thickened Sludge |
| $T_O$ | Thickener Overflow |


0
1
2
3
4
5
RAS
FLOW
PRIMARY EFFLUENT ONLY
RAS + PRIMARY EFFLUENT
LEGEND
*3A
*4A

*For use when only one aerator is in use.

PULLMAN – AERATOR MODES

## PULLMAN – SAMPLING SCHEME

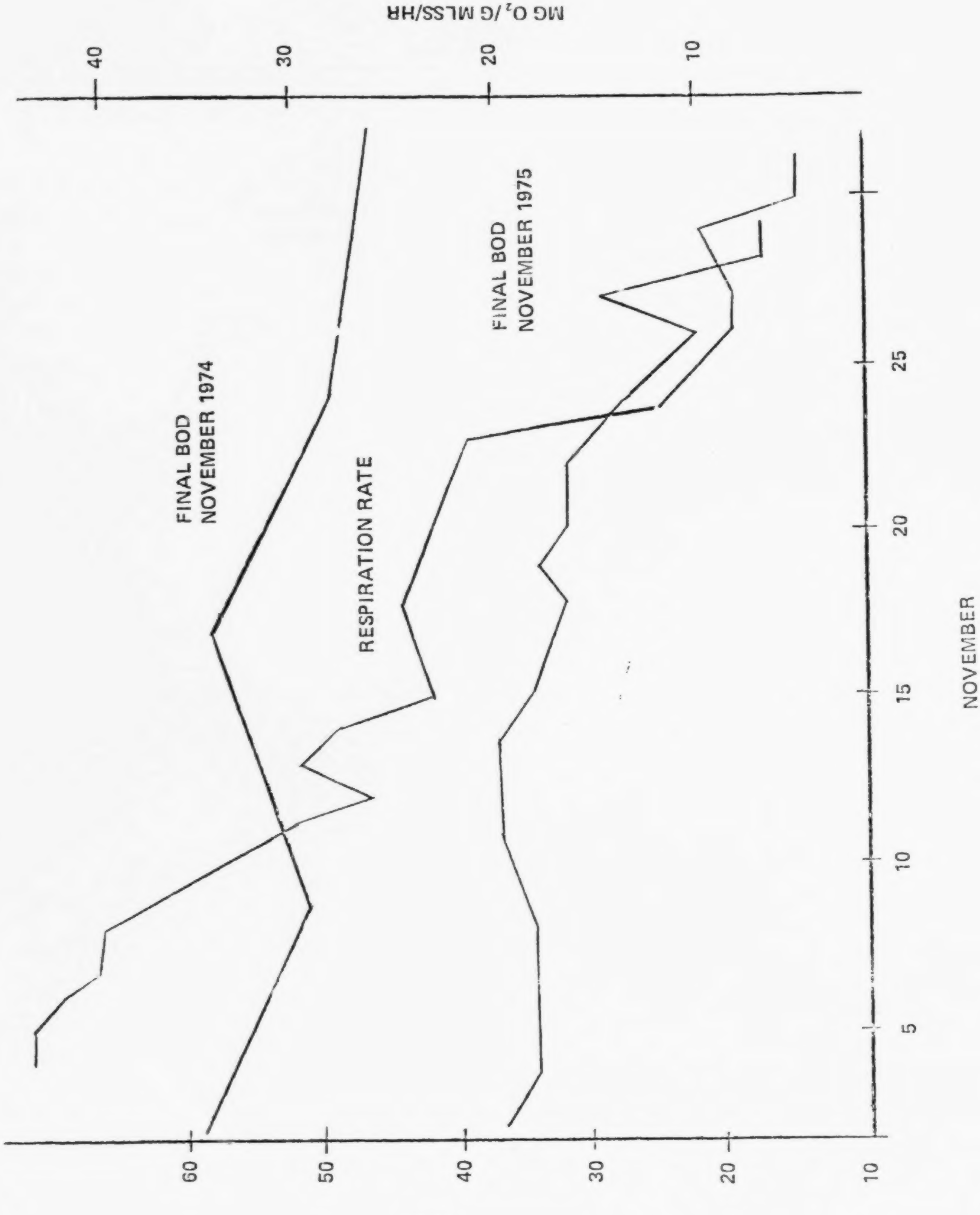

1
P₁
P₂
3
9
XS – 1
PRIMARY CLARIFIER
R-1
R-2
M-1
M-2
2
2
RAW S
R-3
R-4
M-3
M-4
7
$T_O$
GRIT
R-5
R-6
M-5
M-6
PRIMARY DIGESTER
9
TNK
XS – 2
$T_S$
SECONDARY DIGESTER
R
6
4
SECONDARY CLARIFIER
F

### SAMPLE POINTS & FREQUENCY

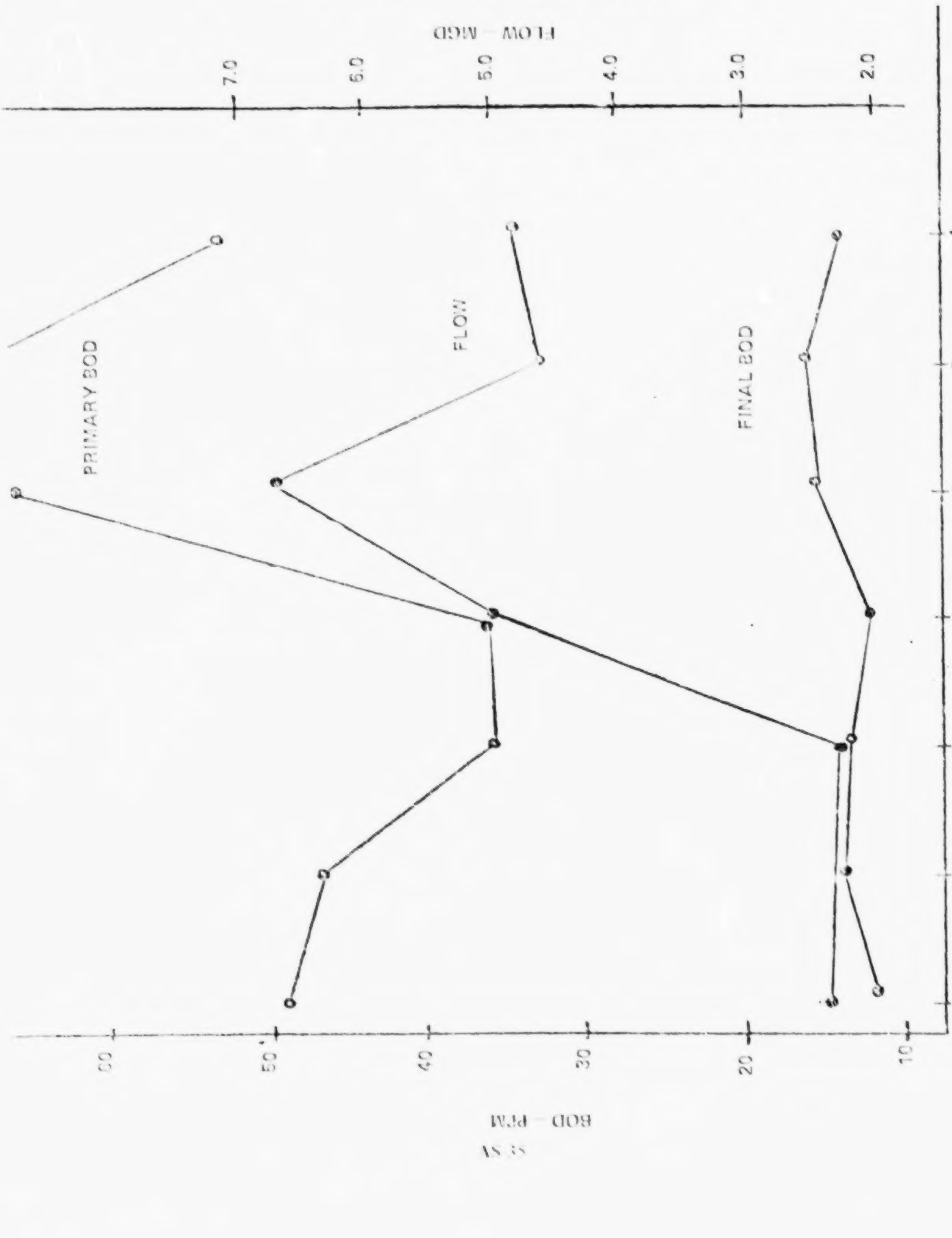
| | Q | Solids | | BOD | % Set | Bl. Depth | Resp. Rate |
|---|---|---|---|---|---|---|---|
| | | Grav. | Cent. | | | | |
| 1 | C | 4/W | – | 4/W | | | |
| 2 | | | 2/d | | | | |
| 3 | | 1/d | 4/d | | 3/d | | 3/d |
| 4 | | | | | | 2/d | |
| 5 | | 4/W | | 4/W | | | |
| 6 | | | 3/d | | | | 3/d |
| 7 | C | ı/d | 4/d | | | | |
| 8 | | | 3/d | | | | 3/d |
| 9 | C | 1/d | 3/d | | | | |

| | |
|---|---|
| P-n | Primary Effluent |
| M-n | Mixed Liquor |
| R-n | Return Sludge |
| F | Final Effluent |
| XS-n | Waste Sludge |
| $T_S$ | Thickened Sludge |
| $T_O$ | Thickener Overflow |

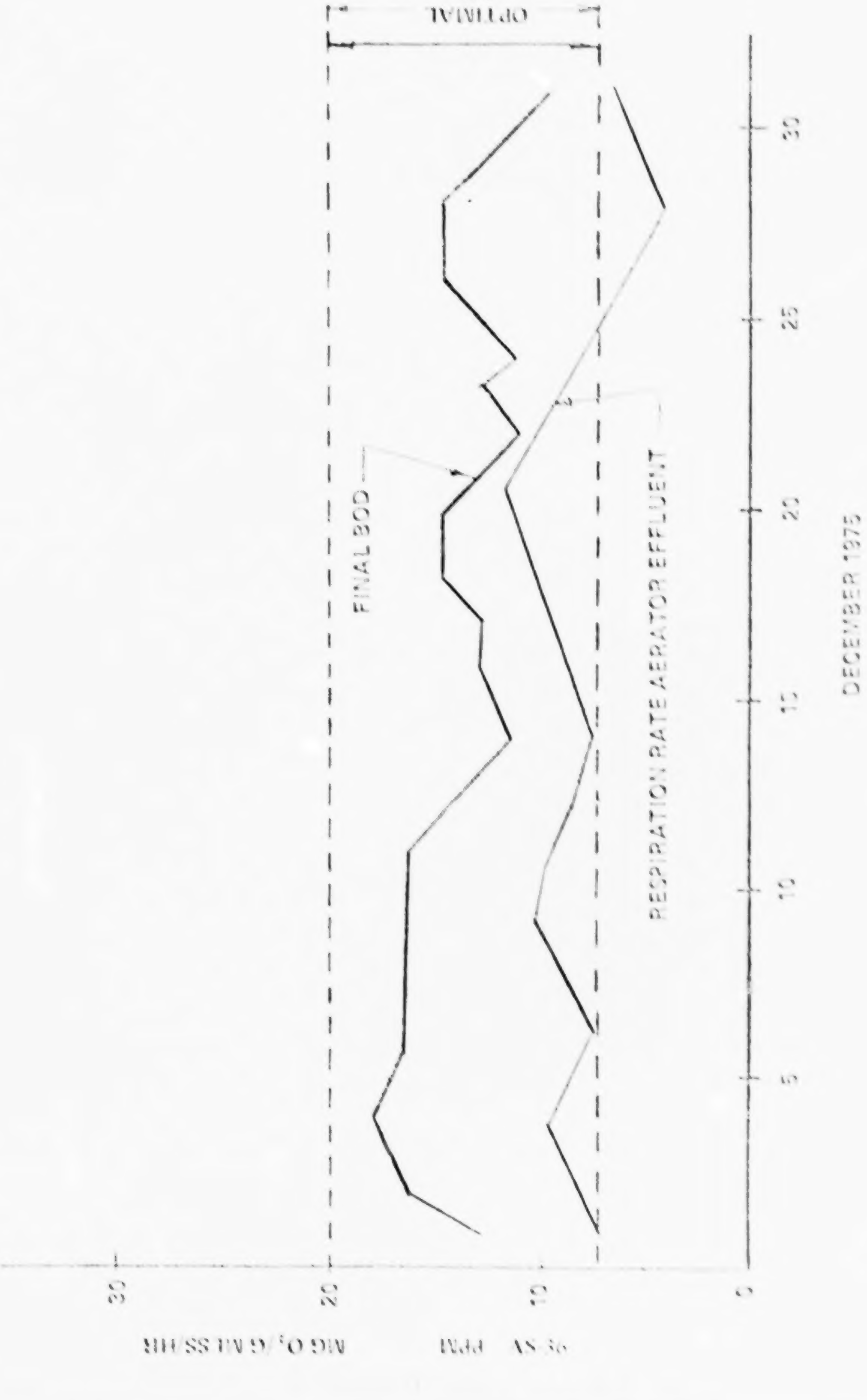
## PULLMAN – NOVEMBER 1975 RESULTS



PULLMAN — 1975 VACATION RESULTS



## PULLMAN – FINAL RESULTS
## DECEMBER 1975



## SPRING AND SUMMER STUDIES
## FOUR EXTENDED AERATION PACKAGE SEWAGE TREATMENT PLANTS
## SUBDIVISION FLOW PATTERN

(mean values)

| | ITEM | INFLUENT | EFFLUENT FULL LOAD | EFFLUENT HALF LOAD |
|---|---|---|---|---|
| 1. | BOD$_5$ (mg/l) | 198.0 | 20.0 | 10.0 |
| 2. | SS (mg/l) | 234.0 | 36.0 | 32.0 |
| 3. | VS (mg/l | 192.0 | 26.0 | 22.0 |
| 4. | COD (mg/l) | 220.0 | 32.0 | 18.0 |
| 5. | % Volatile | 82.0 | 72.0 | 69.0 |
| 6. | pH | 7.5 | 7.1 | 7.2 |
| 7. | Alkalinity (mg/l) | 48.0 | 19.5 | 14.2 |
| 8. | NH$_3$ – N (mg/l) | 17.4 | 0.0 | 0.0 |
| 9. | NO$_3$ – N (mg/l) | | 15.3 | 20.0 |
| 10. | PO$_4$ – P (Total Soluble) (mg/l) | 11.3 | 11.3 | 10.3 |
| 11. | Dissolved Oxygen (mg/l) | | 1.6 | 2.2 |
| 12. | M.B.A.S. (mg/l) | 6.1 | 0.8 | 0.9 |
| 13. | BOD/SS | 0.85 | 0.56 | 0.31 |
| 14. | BOD/VS | 1.03 | 0.77 | 0.45 |
| 15. | BOD/COD | 0.90 | 0.63 | 0.56 |
| 16. | % Reduction | | | |
| | a. BOD$_5$ | | 90.0 | 95.0 |
| | b. SS | | 85.0 | 86.0 |
| | c. VS | | 86.0 | 89.0 |
| | d. COD | | 85.0 | 92.0 |
| | e. Alkalinity | | 59.0 | 71.0 |
| | f. NH$_3$ – N | | 100.0 | 100.0 |
| | g. PO$_4$ P | | 0.0 | 8.8 |
| | h. M.B.A.S. | | 87.0 | 85.0 |
| | | | Mixed Liquor Full Load | Mixed Liquor Half Load |
| 17. | MLSS (mg/l) | | 4,330.0 | 3,050.0 |
| 18. | MLVSS (mg/l) | | 3,120.0 | 2,130.0 |
| 19. | % Volatile | | 72.0 | 70.0 |
| 20. | pH | | 7.3 | 6.9 |
| 21. | SV$_{30}$ (ml) | | 650.0 | 285.0 |
| 22. | Sludge Density Index | | 0.67 | 1.07 |
| 23. | Temperature ($^0$C) | | 18.6 | 18.2 |
| 24. | Dissolved Oxygen (mg/l) | | 2.0 | 3.0 |
| 25. | lb BOD$_5$/lb MLSS | | 0.05 | 0.03 |
| 26. | lb BOD$_5$/lb MLVSS | | 0.06 | 0.05 |

## WINTER AND SPRING STUDIES*
## CONTACT STABILIZATION PACKAGE SEWAGE TREATMENT PLANTS
## FULL DESIGN LOADING – VARIABLE FLOW PATTERN

| | INFLUENT | | | | EFFLUENT | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Item | No. of Samples | Min. | Max. | Mean | No. of Samples | Min. | Max. | Mean | Percent Removal |
| $BOD_5$ (mg/l) | 248 | 112.0 | 305.0 | 184.0 | 236 | 6.0 | 236.0 | 46.0 | 75.0 |
| SS (mg/l) | 252 | 98.0 | 282.0 | 171.0 | 251 | 0.0 | 238.0 | 24.0 | 86.0 |
| VSS (mg/l) | 248 | 88.0 | 234.0 | 145.0 | 248 | 0.0 | 198.0 | 19.0 | 86.9 |
| COD (mg/l) | 244 | 164.0 | 652.0 | 369.0 | 241 | 20.0 | 272.0 | 74.0 | 79.9 |
| $NH_3$ – (mg/l) | 124 | 10.0 | 25.0 | 18.5 | 124 | 1.0 | 20.0 | 10.6 | – |
| $NH_3$ – N (mg/l) | 128 | – | – | *** | 128 | 0.2 | 20.2 | 4.5 | – |
| $PO_4$ P (mg/l) | 120 | 22.0 | 72.0 | 37.2 | 120 | 12.0 | 40.8 | 26.5 | 28.8 |

## MIXED LIQUOR AND STABILIZATION COMPARTMENT SOLIDS

| Item | No. of Samples | Min. | Max. | Mean | Percent Volatile |
|---|---|---|---|---|---|
| MLSS (mg/l) | 252 | 660 | 5,260 | 1,942 | 79.9 |
| MLVSS (mg/l) | 249 | 420 | 4,530 | 1,552 | |
| $SV_{30}$ (ml) | 248 | 50 | 850 | 343 | |
| SVI | 248 | 41 | 495 | 177 | |
| SCSS (mg/l) | 246 | 600 | 8,010 | 2,924 | 80.4** |
| SCVSS (mg/l) | 125 | 850 | 6,640 | 2,492 | |
| RSSS (mg/l) | 540 | 1,000 | 8,400 | 3,485 | 81.6** |
| RSVSS (mg/l) | 43 | 1,170 | 6,400 | 3,332 | |

---

* These data were collected during the period of criteria development and are not the result of testing under the conditions established for certification testing.

** Calculated from paired samples only.

*** The mean $NO_3$ – N in the influent for this series of data was 0.2 mg/l.

## SPRING AND SUMMER STUDIES *
## CONTACT STABILIZATION PACKAGE SEWAGE TREATMENT PLANTS
## FULL DESIGN LOADING – VARIABLE FLOW PATTERN

| | INFLUENT | | | | EFFLUENT | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Item | No. of Samples | Min. | Max. | Mean | No. of Samples | Min. | Max. | Mean | Percent Removal |
| $BOD_5$ (mg/l) | 87 | 100.0 | 297.0 | 167.0 | 86 | 1.0 | 220.0 | 37.0 | 77.8 |
| SS (mg/l) | 88 | 126.0 | 344.0 | 184.0 | 88 | 3.0 | 318.0 | 45.0 | 75.5 |
| VSS (mg/l) | 88 | 70.0 | 278.0 | 149.0 | 88 | 0.0 | 218.0 | 35.0 | 76.5 |
| MBAS (mg/l) | 83 | 1.9 | 10.0 | 5.6 | 83 | 0.0 | 2.4 | 0.6 | 89.3 |
| COD (mg/l) | 88 | 140.0 | 676.0 | 368.0 | 88 | 16.0 | 392.0 | 89.0 | 75.8 |
| $NH_3 - N$ (mg/l) | 88 | 6.0 | 22.1 | 17.1 | 88 | 3.3 | 22.1 | 10.7 | – |
| $NO_3 - N$ (mg/l) | 88 | – | – | ** | 88 | 0.3 | 16.0 | 3.5 | – |
| $PO_4 - P$ (mg/l) | 87 | 21.0 | 80.0 | 52.9 | 87 | 23.2 | 53.6 | 36.3 | 31.4 |

## MIXED LIQUOR AND STABILIZATION COMPARTMENT SOLIDS

| Item | No. of Samples | Min. | Max. | Mean | Percent Volatile |
|---|---|---|---|---|---|
| MLSS (mg/l) | 91 | 1,300 | 6,650 | 3,406 | 75.2 |
| MLVSS (mg/l) | 91 | 970 | 4,550 | 2,561 | |
| $SV_{30}$ (ml) | 91 | 90 | 950 | 531 | |
| SVI | 91 | 39 | 486 | 156 | |
| SCSS (mg/l) | 68 | 2,970 | 8,460 | 5,572 | 76.5 |
| SCVSS (mg/l) | 68 | 2,270 | 6,840 | 4,264 | |
| RSSS (mg/l) | 91 | 1,110 | 11,580 | 6,935 | 73.0 |
| RSVSS (mg/l) | 91 | 740 | 8,830 | 5,062 | |

* These data were collected during the period of criteria development and are not the result of testing under the conditions established for certification testing.

** The mean $NO_3 - N$ in the influent for this series of data was 0.4 mg/l.

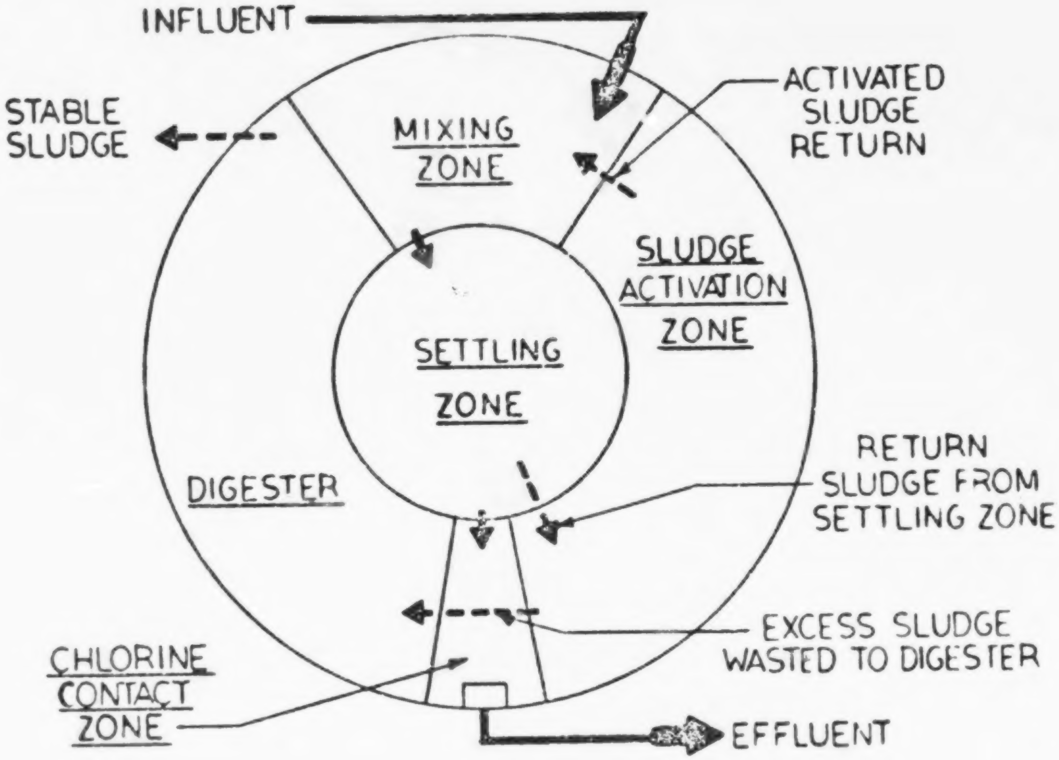
## TROUBLESHOOTING GUIDE – EXTENDED AERATION PLANTS

| CASE NO. | AERATION TANK SAMPLE JAR CONDITIONS | PLANT EFFLUENT SAMPLE JAR CONDITIONS | INTERPRETATION | CONFIRMATORY PLANT CONDITION OBSERVATIONS | ACTION REQUIRED |
|---|---|---|---|---|---|
| I | Heavy, rapid settling, brown sludge occupying 10 – 70% of the jar volume. Clear liquid above sludge. Faint musty, earthy odor. | Light dusting of fine pinpoint solids on bottom. Clear liquid above. Faint musty odor. | Plant in good operating condition | No objectionable odors. Clear effluent. No black or brown sludge floating on surface of settling tank. | None |
| II | Same as Case I. | Relatively large volume of sludge on bottom of jar – 1/8 in. or more thick. Faint musty odor. | Excessive loss of solids because of too high a flow rate through settling basin. | Flow into plant abnormally high. Indicated by measuring weir or depth of flow in inlet or outlet sewer. | Check sewer system for stormwater infiltration or unusual water discharges. If lift station precedes plant, reduce discharge rate. |
| III | Very heavy but good settling brown sludge occupying 70% of jar volume or more. Unobjectionable musty odor. | Very large volume of brown sludge on bottom of jar. Musty odor. | Excessive loss of solids because of too high a solids concentration in aeration tank. | Heavy solids concentration in settling basin for entire depth and solids discharging over effluent trough weirs. | Remove solids from system by pumping to tank truck and hauling to farm land or dump. |
| IV | Poor separation of solids from liquid. Little clear liquid. Brown fluffy sludge hangs in liquid or floats on water surface. Faint musty, earthy odor. | Relatively little settling of solids. Fluffy solids in suspension in liquid and floating at surface. Faint musty odor. Little clear liquid. | Denitrification in settling basin releases nitrogen gas causing sludge to float. | No objectionable odor in aeration tank. Blanket of brown sludge over surface of settling basin which will gradually turn septic if not removed. | Reduce air supply. Increase rate of returning sludge to aeration tank if possible to reduce settling basin retention time. |
| V | Heavy, rapid settling, dark brown or dark gray to black sludge occupying 15 – 70% of jar volume. Cloudy or turbid liquid above sludge. Musty or faint septic (sour) sewage odor. | Relatively more solids than in Case I. Bottom of jar covered with distinct layer of sludge. Liquid cloudy to turbid. Noticeably septic odor. | Deficiency in animal predators (protozoa) to feed on bacteria, probably caused by too little air but possibly by abnormal pH (acidity or alkalinity), if septic conditions are not present. | Aeration tank contents abnormally dark with possible septic odor. Cloudy effluent with possible septic odor. | Increase air supply. Check pH if septic conditions are not present. Add lime or soda ash if pH is below 6.0. Add acid if pH is above 9.0. Check for industrial wastes. Eliminate if found. |
| VI | Very heavy, fair settling, dark gray or black sludge occupying 50% of jar volume or more. Septic odor. | Same as Case III, except sludge is dark gray or black instead of brown. | Too little air for heavy solids load and excessive loss of solids in plant effluent because of too high a solids load in aeration tank. | Same as Case III except solids are dark gray or black instead of brown. | Increase air supply if possible and waste solids as in Case II. Check for overload and add treatment capacity if needed. |

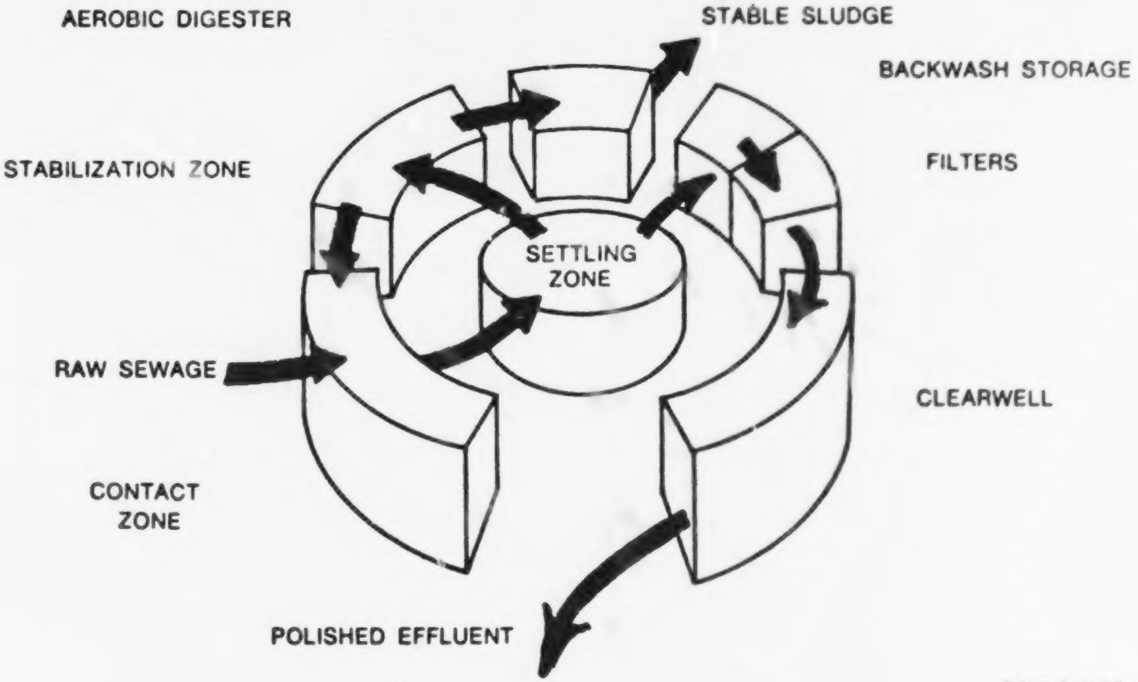
## SMALL PACKAGE PLANT DAILY CHECKLIST*

1. Clean bar screen and pick up sample for raw settleable solids test
2. Notice conditions of floc
3. Notice conditions of aeration chamber
4. Notice conditions of sludge return
5. Check for foam on aeration chamber
6. Final Clarifier:
    a. Check surface skimmer
    b. Check appearance of clarifier liquid
    c. Clean weir troughs
    d. Squeegee solids
    e. Check level of sludge blanket
    f. Remove any leaves, etc from surface
    g. Pick up sample for final effluent settleable solids test
    h. Check chlorine residual
7. Air Compressors:
    a. Visually inspect motors
    b. Listen for any unusual noises
    c. Rotate motors and change compressors
    d. Inspect motors for overheating
    e. Check oil levels
    f. Grease motors if needed
    (Motors should be greased as specified by the manufacturers. Normally, when manufacturing information is not available, two small shots of grease every 6 months is sufficient)
    g. Inspect Hypochlorinator:
        1. Determine HTH level
        2. Check discharge line

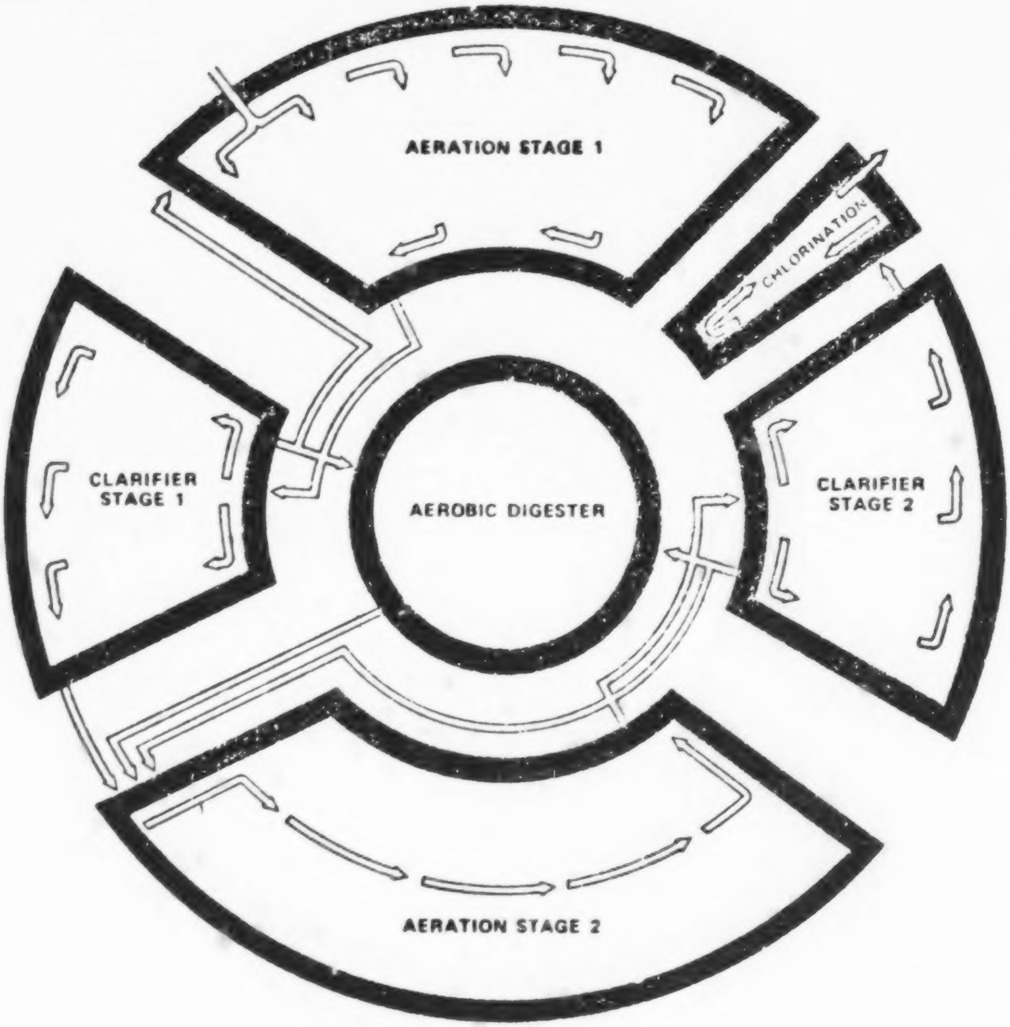
* Provided by the Texas Water Quality Board


INFLUENT
STABLE SLUDGE
MIXING ZONE
ACTIVATED SLUDGE RETURN
SLUDGE ACTIVATION ZONE
SETTLING ZONE
DIGESTER
RETURN SLUDGE FROM SETTLING ZONE
EXCESS SLUDGE WASTED TO DIGESTER
CHLORINE CONTACT ZONE
EFFLUENT

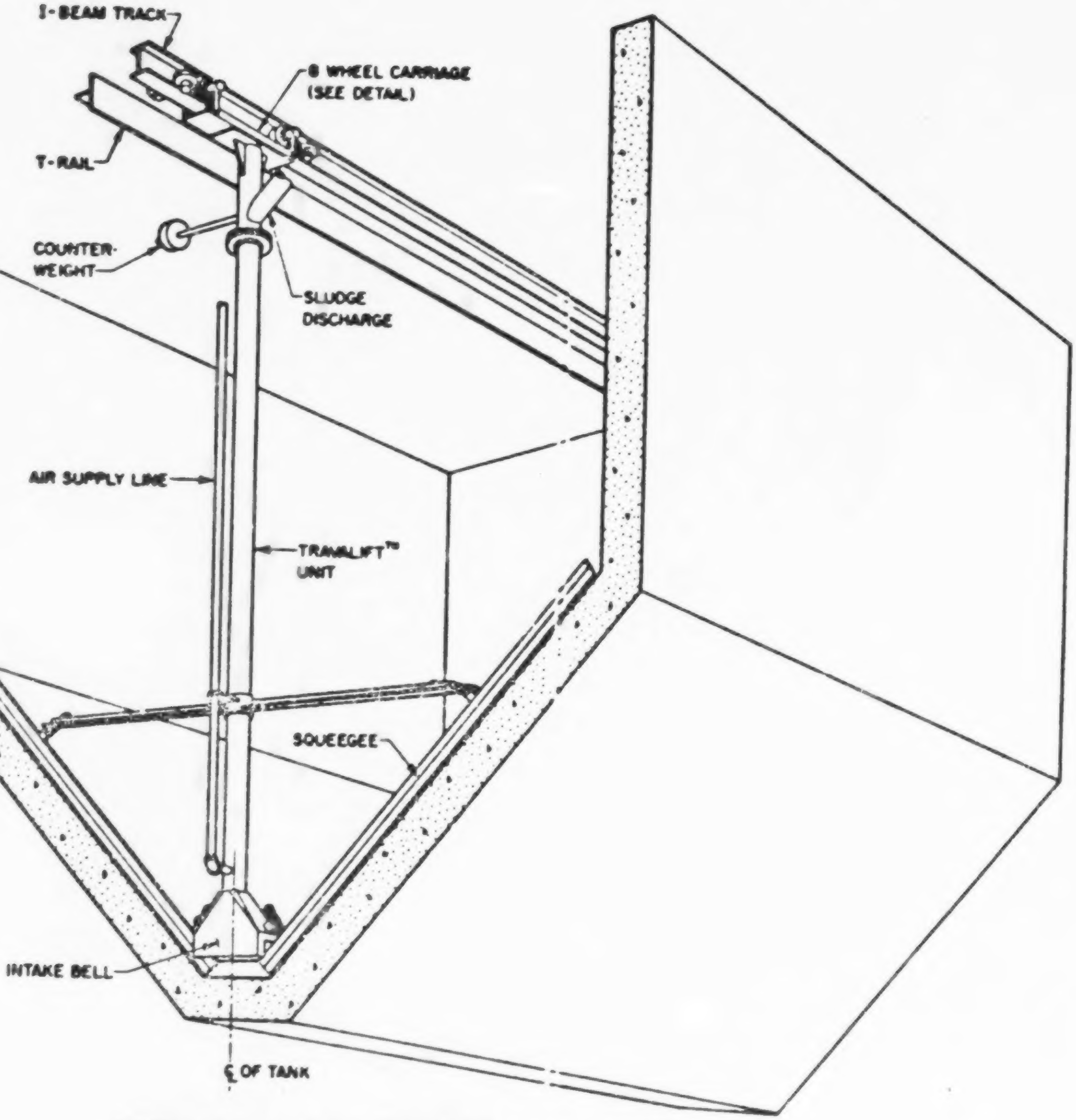
Flow Diagram - Contact Stabilization
Package Treatment Plant


AEROBIC DIGESTER
STABLE SLUDGE
BACKWASH STORAGE
STABILIZATION ZONE
FILTERS
SETTLING ZONE
RAW SEWAGE
CLEARWELL
CONTACT ZONE
POLISHED EFFLUENT
Patents Applied For

Flow Diagram - Circular Plant With Tertiary Treatment

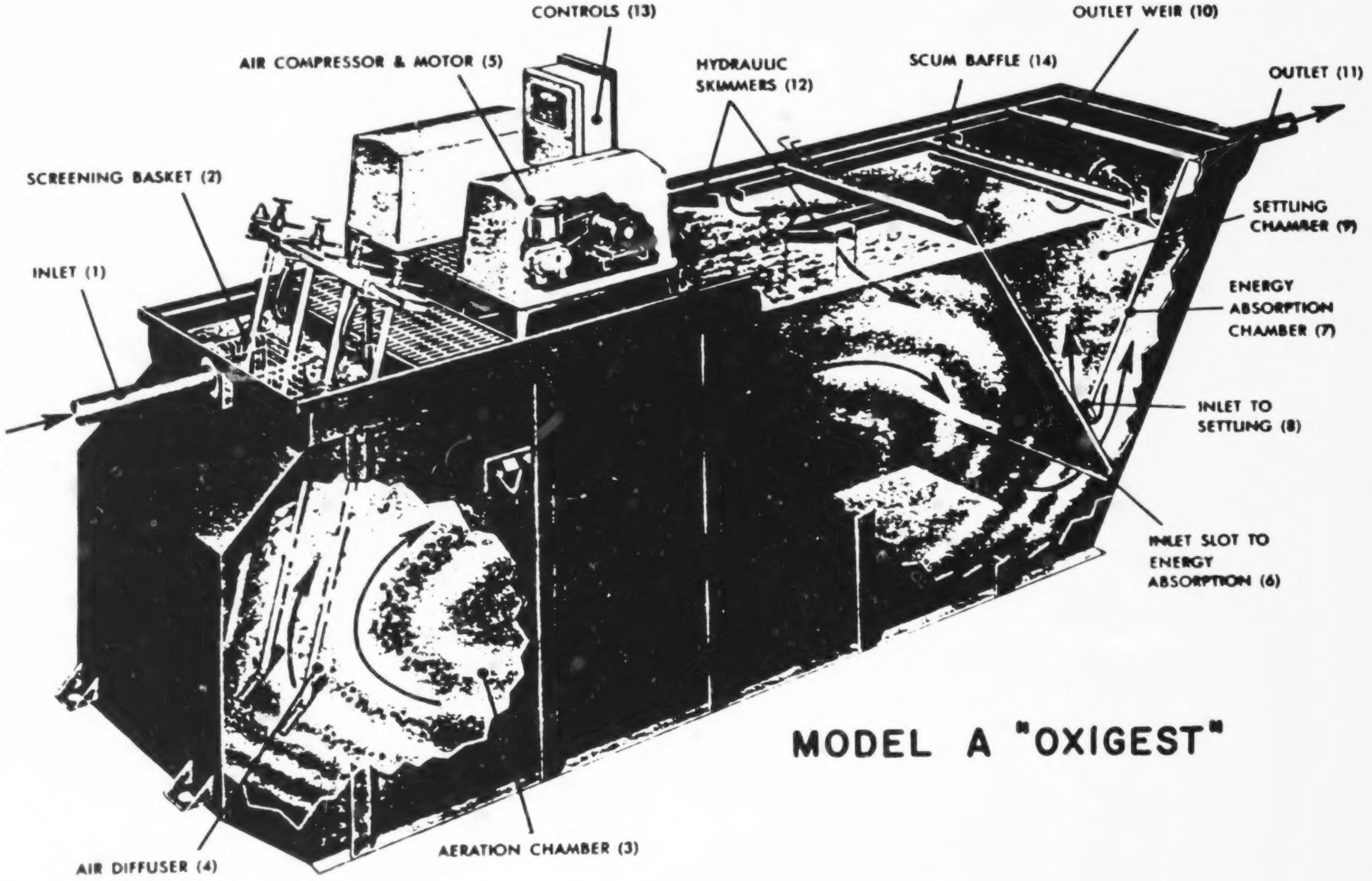

AERATION STAGE 1
CHLORINATION
CLARIFIER STAGE 1
AEROBIC DIGESTER
CLARIFIER STAGE 2
AERATION STAGE 2

Flow Diagram - Alternative Circular Configuration


I-BEAM TRACK
8 WHEEL CARRIAGE (SEE DETAIL)
T-RAIL
COUNTER-WEIGHT
SLUDGE DISCHARGE
AIR SUPPLY LINE
TRAVALIFT™ UNIT
SQUEEGEE
INTAKE BELL
℄ OF TANK

TRAVALIFT INSTALLATION

Moving Suction System In A Rectangular Plant


CONTROLS (13)
AIR COMPRESSOR & MOTOR (5)
OUTLET WEIR (10)
HYDRAULIC SKIMMERS (12)
SCUM BAFFLE (14)
OUTLET (11)
SCREENING BASKET (2)
SETTLING CHAMBER (9)
INLET (1)
ENERGY ABSORPTION CHAMBER (7)
INLET TO SETTLING (8)
INLET SLOT TO ENERGY ABSORPTION (6)
MODEL A "OXIGEST"
AIR DIFFUSER (4)
AERATION CHAMBER (3)

Rectangular Oxigester Plant

## REFERENCES – ACTIVATED SLUDGE

National Waste Treatment Center. Operational Control Procedures for the Activated Sludge Process. Environmental Protection Agency, Cincinnati, Ohio.

Stevens, Thompson & Runyon, Inc. Operator's Pocket Guide to Activated Sludge, Pamphlets, Parts I & II. Portland, Oregon.

Jim Nemke. Visual Observations Can be Process Control Aids. Water Pollution Control Federation Deeds & Data, September 1975.

J. Edward Meers. Activated Sludge Process and Operation Control. In: The Digester, State of Illinois, May 1975.

W. D. Hatfield. Operation of the Activated Sludge Process. Journal, Water Pollution Control Federation, June, 1966.

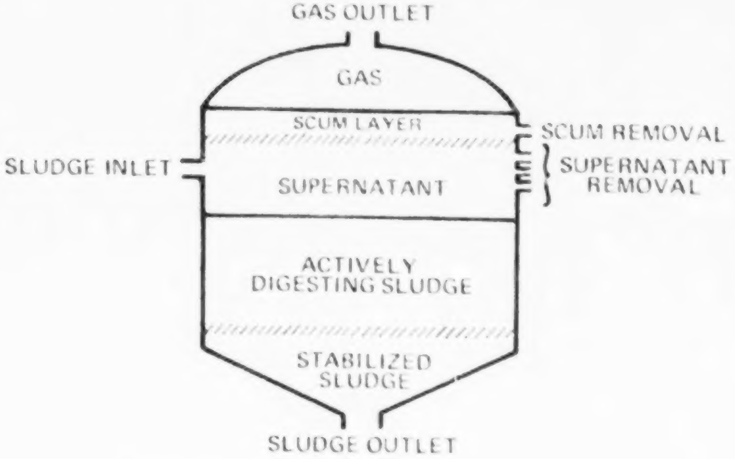
Sherrard & Kincannon. Operational Control Concepts for the Activated Sludge Process. Water & Sewage Works, March, 1974.

# STUDENT NOTEBOOK MATERIALS

## Index of Notebook Materials

| Pages | Material | Use in Lesson |
|---|---|---|
| SH – 1 thru SH – 3 | Process diagrams, anaerobic digestion | Reference by instructor, Subdivision 1 |
| SH – 4 | Start-up Procedure for Digesters | Same as above |
| SH – 5 | Chart – Sludge Treatment Processes | Reference by instructor Subdivision 3, Section I |
| SH – 6 | Chart – Unit Processes, Sludge Processing and Disposal | Same as above |
| SH – 7 | Process diagram, Gravity Thickener | Reference by instructor Subdivision 3, Section II |
| SH – 8 | Troubleshooting Guide, Gravity Thickeners | Same as above |
| SH – 9 | Process diagram, Flotation Unit | Reference by instructor Subdivision 3, Section III |
| SH – 10 | Troubleshooting Guide, Dissolved Air Flotation Thickening | Same as above |
| SH – 11 & SH – 12 | Process diagrams, Centrifuges | Reference by instructor Subdivision 3, Section IV |
| SH – 13 | Troubleshooting Guide, Sludge Centrifugation | Same as above |
| SH – 14 & SH – 15 | Process diagrams, Aerobic Digestion | Reference by instructor Subdivision 3, Section V |
| SH – 16 | Troubleshooting Guide, Aerobic Digestion | Same as above |
| SH – 17 | Troubleshooting Guide, Sludge Drying Beds | Reference by instructor Subdivision 3, Section VI |
| SH – 18 | Process diagrams, Vacuum Filters | Reference by instructor Subdivision 3, Section VII |
| SH – 19, 20 | Troubleshooting Guide, Vacuum Filtration | Same as above |
| SH – 21 | References | |

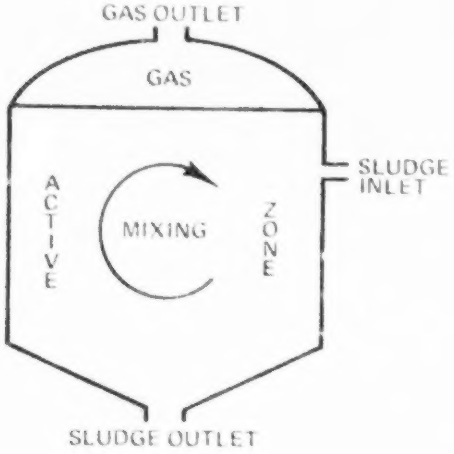
Reproduced from EPA Manual "Sludge Treatment and Disposal"


GAS OUTLET
GAS
SCUM LAYER
SCUM REMOVAL
SLUDGE INLET
SUPERNATANT
SUPERNATANT REMOVAL
ACTIVELY DIGESTING SLUDGE
STABILIZED SLUDGE
SLUDGE OUTLET

(A)

STANDARD RATE DIGESTION

1. UNHEATED
2. DETENTION TIME 30 – 60 DAYS
3. LOADING 0.03 – 0.10 lb. VSS/cu. ft./day
4. INTERMITTENT FEEDING AND WITHDRAWAL
5. STRATIFICATION

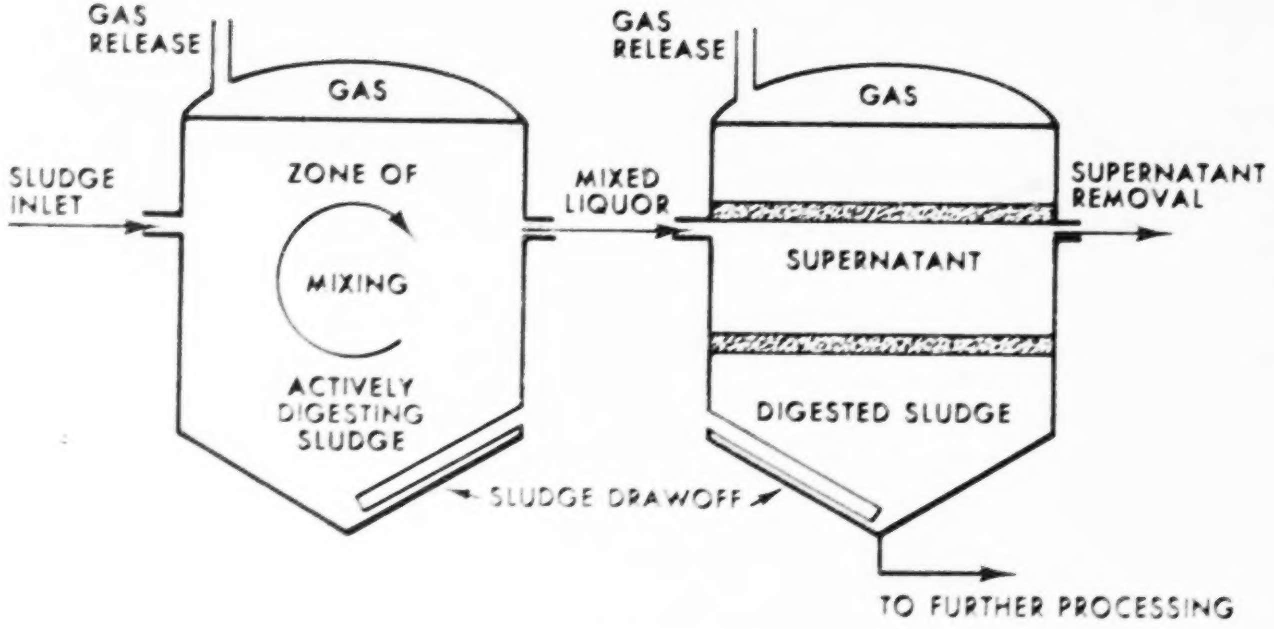

GAS OUTLET
GAS
SLUDGE INLET
ACTIVE
MIXING
ZONE
SLUDGE OUTLET

(B)

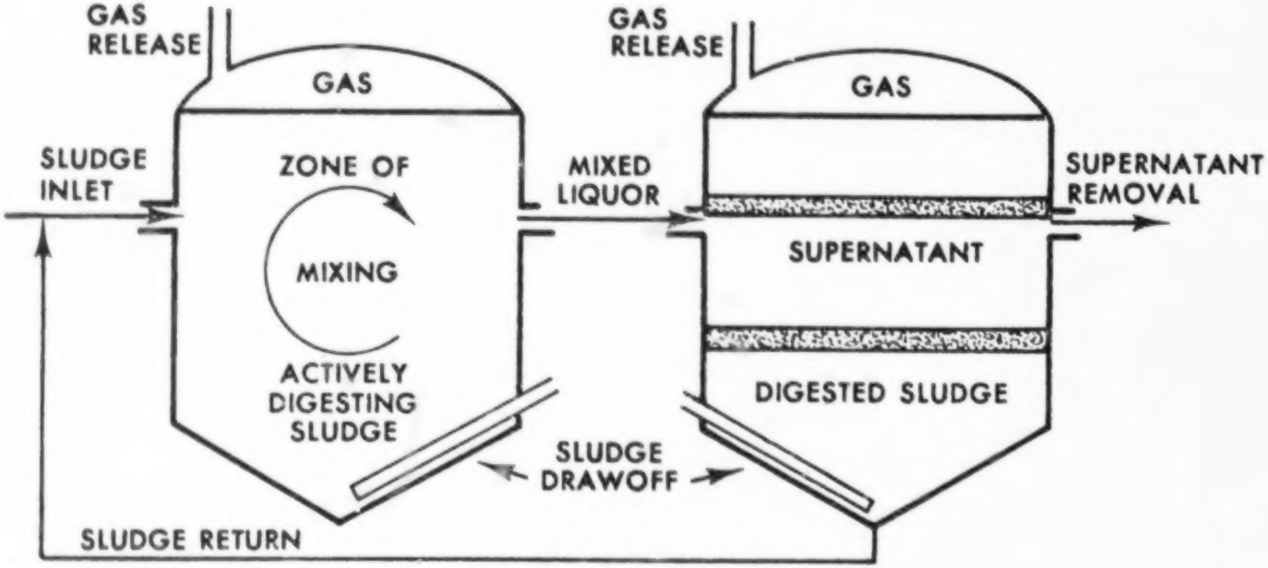
HIGH RATE DIGESTION

1. HEATED TO 85° – 95° F
2. DETENTION TIME 15 DAYS OR LESS
3. LOADING 0.10 – 0.50 lb. VSS/cu. ft./day
4. CONTINUOUS OR INTERMITTENT FEEDING AND WITHDRAWAL
5. HOMOGENEITY

STANDARD RATE AND HIGH RATE DIGESTION


GAS RELEASE
GAS
SLUDGE INLET
ZONE OF
MIXING
ACTIVELY DIGESTING SLUDGE
MIXED LIQUOR
GAS RELEASE
GAS
SUPERNATANT REMOVAL
SUPERNATANT
DIGESTED SLUDGE
SLUDGE DRAWOFF
TO FURTHER PROCESSING

TWO STAGE ANAEROBIC DIGESTION


GAS RELEASE
GAS
SLUDGE INLET
ZONE OF
MIXING
ACTIVELY DIGESTING SLUDGE
MIXED LIQUOR
GAS RELEASE
GAS
SUPERNATANT REMOVAL
SUPERNATANT
DIGESTED SLUDGE
SLUDGE DRAWOFF
SLUDGE RETURN

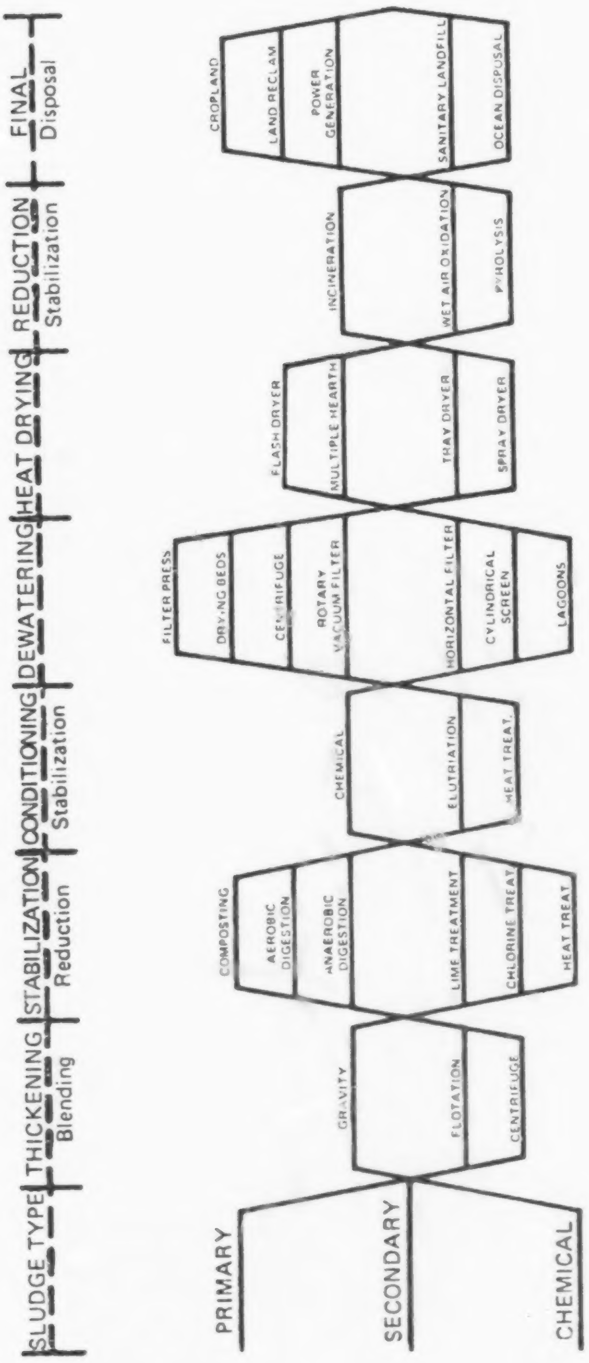
ANAEROBIC CONTACT DIGESTION

## START UP PROCEDURE FOR DIGESTERS

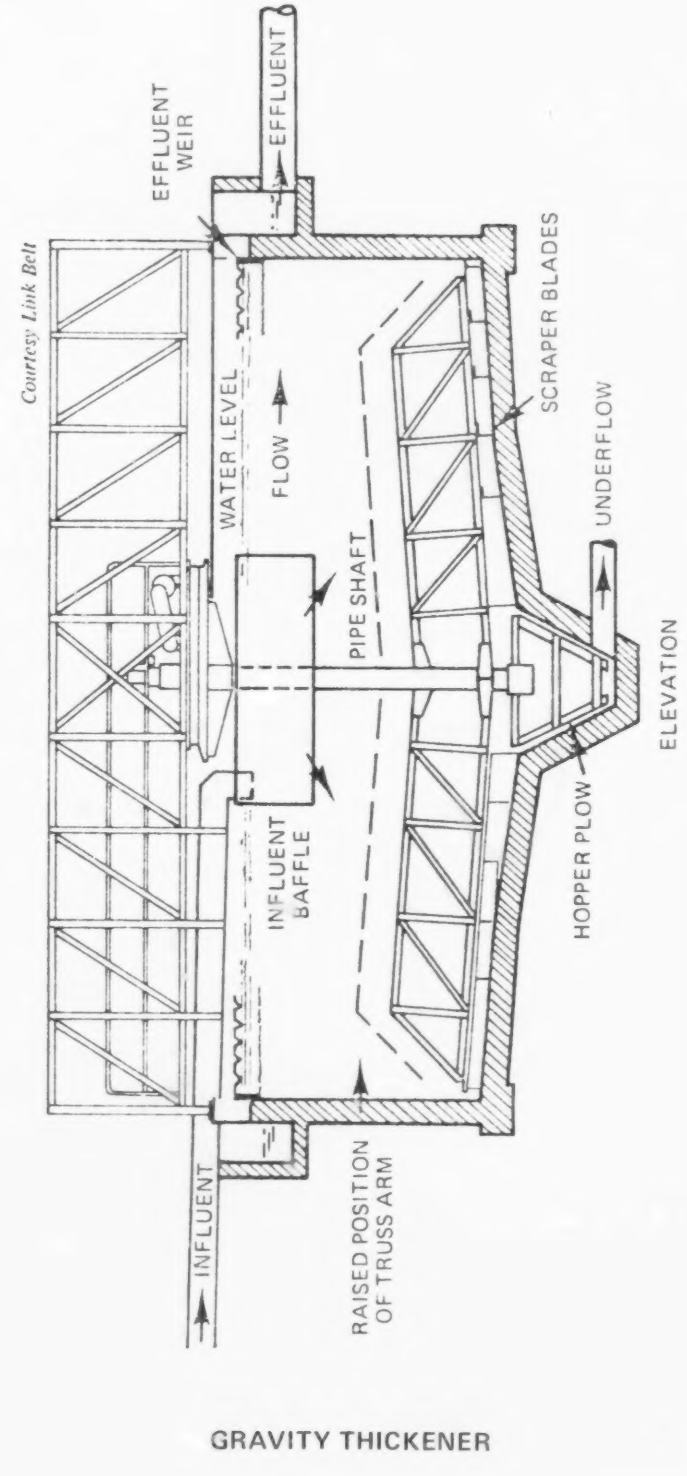
1. Fill with raw sewage
2. Heat to desired temperature (approx. 95°F)
3. Feed digester at 0.01 lb of VM/ft$^3$/day
4. Compute volatile acids, alkalinity, plus pH daily
5. Buffer the system with lime or sodium carbonate
6. Plot volatile acid concentration as a function of time
7. Mix digester continuously if possible and maintain constant temperature
8. As soon as volatile acid concentration starts to drop rapidly increase loading by 0.01 lbs of VM/ft$^3$/day
9. Continue until full load is on system
10. Seed sludge can be added to accelerate the start up process provided it can be added in sufficient quantity (10% of tank volume) and not be cooled or aerated in the transfer process

| UNIT PROCESSES | FUNCTIONS |
|---|---|
| Thickening (Blending) | – Water Removal<br>– Volume Reduction<br>– Post Process Efficiencies<br>– Blending |
| Stabilization (Reduction) | – Pathogen Destruction<br>– Volume and Weight Reduction<br>– Odor Control<br>– Putrescibility Control<br>– Gas Production |
| Conditioning (Stabilization) | – Improve Dewatering or Thickening Rate<br>– Improve Solids Capture<br>– Improve Compactability<br>– Stabilization |
| Dewatering | – Water Removal<br>– Volume and Weight Reduction<br>– Change to Damp Cake<br>– Reduces Fuel Requirements for Incineration/Drying |
| Heat Drying | – Water Removal<br>– Sterilization<br>– Utilization |
| Reduction (Stabilization) | – Destruction of Solids<br>– Water Removal<br>– Conversion<br>– Sterilization |
| Final Disposal | – Utilization (Cropland)<br>– Utilization (Energy)<br>– Utilization (Land Reclamation)<br>– Disposal (Landfill)<br>– Disposal (Ocean) |

SLUDGE TREATMENT PROCESSES


SLUDGE TYPE
THICKENING
Blending
STABILIZATION
Reduction
CONDITIONING
Stabilization
DEWATERING
HEAT DRYING
REDUCTION
Stabilization
FINAL
Disposal
PRIMARY
SECONDARY
CHEMICAL
GRAVITY
FLOTATION
CENTRIFUGE
COMPOSTING
AEROBIC DIGESTION
ANAEROBIC DIGESTION
LIME TREATMENT
CHLORINE TREAT
HEAT TREAT
CHEMICAL
ELUTRIATION
HEAT TREAT.
FILTER PRESS
DRYING BEDS
CENTRIFUGE
ROTARY VACUUM FILTER
HORIZONTAL FILTER
CYLINDRICAL SCREEN
LAGOONS
FLASH DRYER
MULTIPLE HEARTH
TRAY DRYER
SPRAY DRYER
INCINERATION
WET AIR OXIDATION
PYROLYSIS
CROPLAND
LAND RECLAM
POWER GENERATION
SANITARY LANDFILL
OCEAN DISPOSAL

UNIT PROCESSES – SLUDGE PROCESSING AND DISPOSAL



EFFLUENT WEIR
EFFLUENT
WATER LEVEL
FLOW
PIPE SHAFT
SCRAPER BLADES
UNDERFLOW
ELEVATION
HOPPER PLOW
INFLUENT BAFFLE
RAISED POSITION OF TRUSS ARM
INFLUENT

*Courtesy Link Belt*

GRAVITY THICKENER

# TROUBLESHOOTING GUIDE – SOLIDS HANDLING

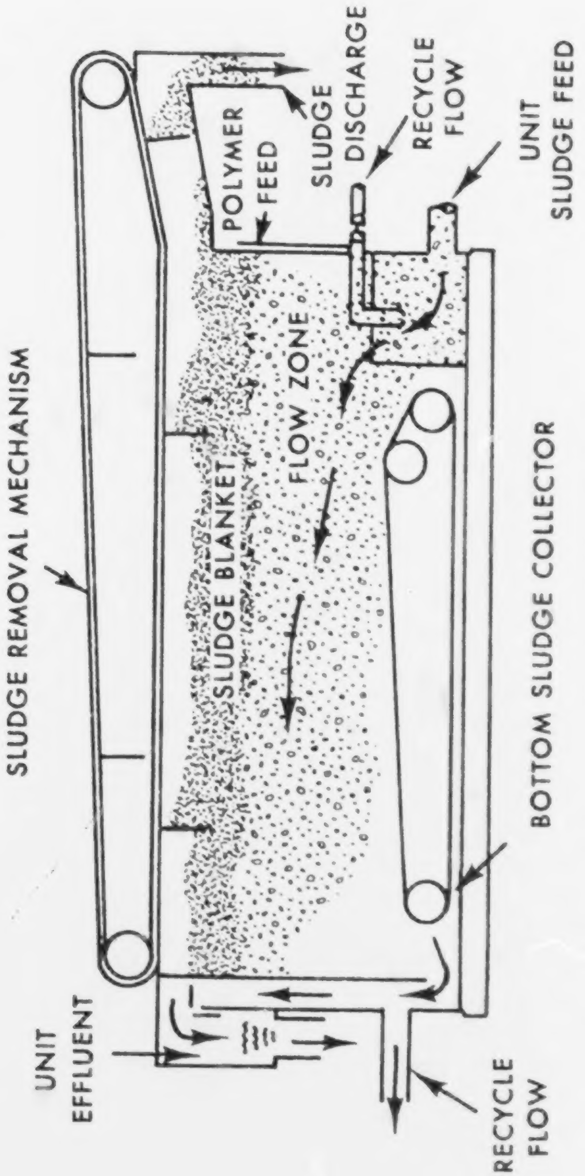
## I. GRAVITY THICKENERS

### A. Process Evaluation Measures

1. Determine the hydraulic loading
2. Determine the solids loading
3. Compute a mass balance around the system
4. Determine the IOD of the system (Immediate Oxygen Demand)

### B. Problem Identification and Correction

1. Low thickened sludge concentration
    - a. Possible cause – over pumping of thickened sludge, or pumping at improper rate
        - 1. Characterized by:
            - a. Hydraulic and solids loading, normal
            - b. Mass balance, normal
            - c. Supernatant within specs, low IOD, solids, normal
            - d. No odor
            - e. No gas bubbles
        - 2. Corrective measure:
            - a. Modify sludge pumping rate from thickener by computing required rate
    - b. Possible cause – thickener becomes septic
        - 1. Characterized by:
            - a. Odor from thickener
            - b. High IOD in supernatant
            - c. High solids in supernatant
            - d. Septic liquified thickened sludge
            - e. High volatile acid concentration in thickened sludge (73,000 mg/l)
        - 2. Corrective measures
            - a. Increase sludge pumping
            - b. Add chlorine
            - c. Drain thickener contents, to digester wash down and start over again
            - d. The above corrective measures should be attempted in sequence where (c) is the most drastic measure
            - e. Check pumps, valves
            - f. Reduce possible overloading of tank
            - g. Add air 1 to 2 feet below surface, or in wet well
            - h. Recycle up to hydraulic load capacity

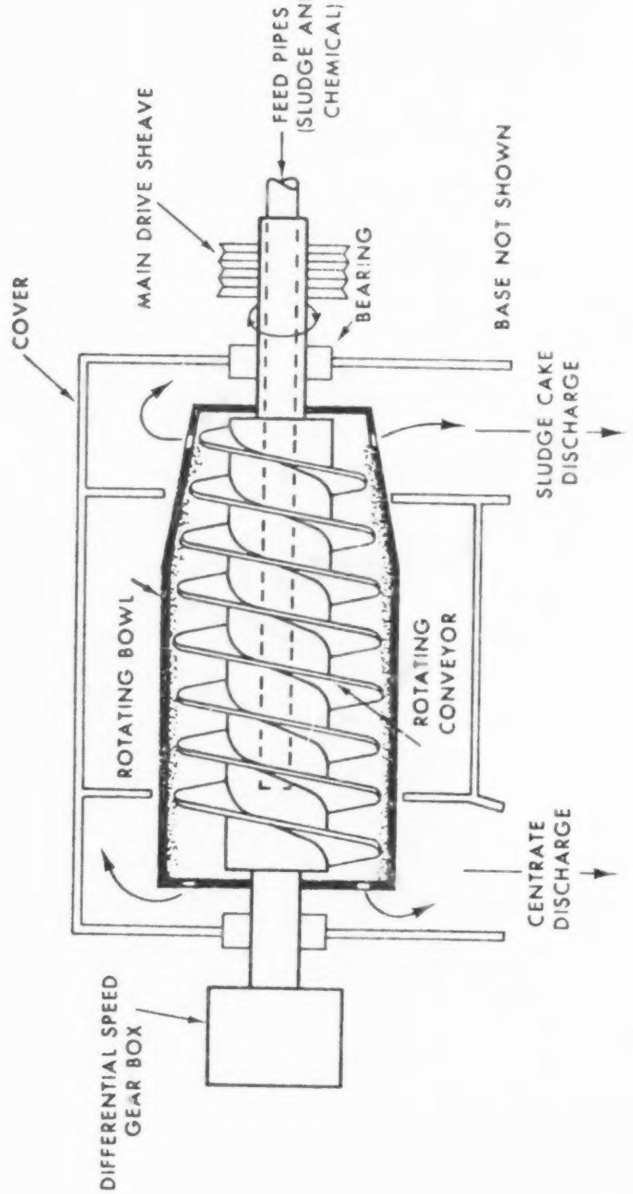

SLUDGE REMOVAL MECHANISM
SLUDGE BLANKET
FLOW ZONE
BOTTOM SLUDGE COLLECTOR
POLYMER FEED
SLUDGE DISCHARGE
RECYCLE FLOW
UNIT SLUDGE FEED
UNIT EFFLUENT
RECYCLE FLOW

FLOTATION UNIT

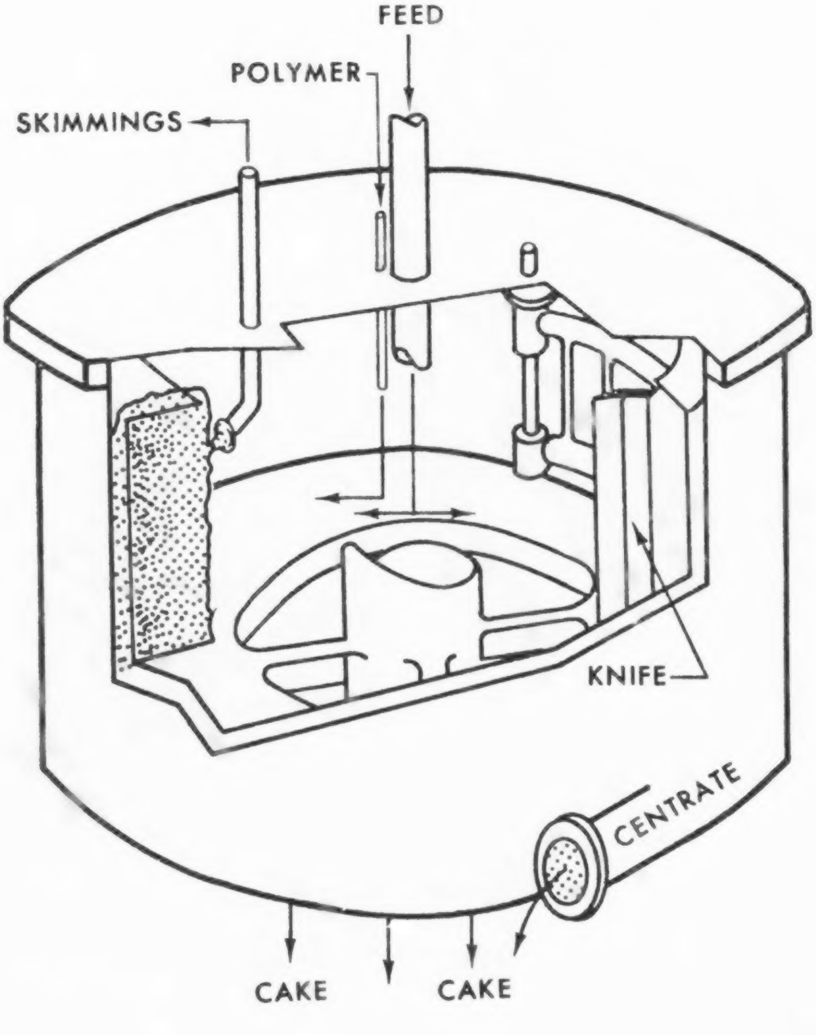
# TROUBLESHOOTING GUIDE – SOLIDS HANDLING

## II. DISSOLVED AIR FLOTATION THICKENING

- A. Process Evaluation Measures
  - 1. Determine hydraulic loading
  - 2. Determine solids loading
  - 3. Determine average float solids concentration
  - 4. Determine average subnatant solids concentration
  - 5. Compute mass balance around the system
- B. Problem Identification and Correction
  - 1. Low float solids concentration
    - a. Possible cause – excessive skimming
      - 1. Characterized by:
        - a. hydraulic loading – normal
        - b. Solids loading – normal
        - c. Float OK – not frothy due to excessive air
        - d. Air to solids ratio – normal
      - 2. Corrective measures – reduce skimmer speed to maximum thickness without having excessive solids carry over.
    - b. Possible cause – excessive air/solids ratio
      - 1. Characterized by:
        - a. Hydraulic loading, OK
        - b. Solids loading, OK
        - c. Float extremely frothy
      - 2. Corrective measures
        - a. Reduce air to pressurization system, or
        - b. Increase solids load to thickener
        - c. Obtain recycle rate of 1:1 to 3:1
  - 2. Poor Capture
    - a. Possible causes –
      - 1. Hydraulically overloaded
      - 2. High solids loading
      - 3. Low A/S ratio
      - 4. Low removal or skimming rate
      - 5. Poor rise rate
    - b. Hydraulic or solids overload
      - 1. Check first, if satisfactory then check
    - c. A/S solids loading
      - 1. Check, characterized by poor float formation solids settling to the bottom. If normal, then check
    - d. Skimming rate
      - 1. Characterized by good thick float, but excessively deep to the point where it is coming up under the baffle if rate is too low. If normal, then check
    - e. Poor rise rate
      - 1. Characterized by high sludge volume index, poor float density, and dispersed floc


FEED PIPES (SLUDGE AND CHEMICAL)
MAIN DRIVE SHEAVE
BEARING
BASE NOT SHOWN
COVER
SLUDGE CAKE DISCHARGE
ROTATING BOWL
ROTATING CONVEYOR
CENTRATE DISCHARGE
DIFFERENTIAL SPEED GEAR BOX

SOLID BOWL CENTRIFUGE
WITH CONVEYOR DISCHARGE AND CONTINUOUS COUNTERCURRENT


FEED
POLYMER
SKIMMINGS
KNIFE
CENTRATE
CAKE
CAKE

BASKET CENTRIFUGE

## III. SLUDGE CENTRIFUGATION

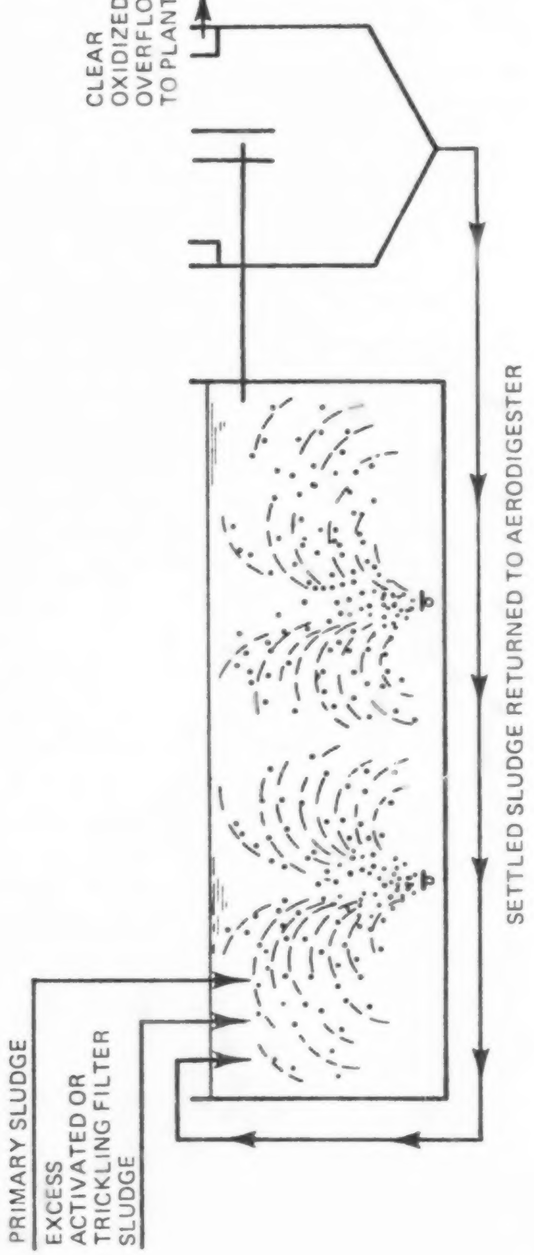
### A. Process Evaluation Measures

NOTE: It is not possible to give exact procedures as to process evaluation without knowing the exact design intent. Normally in anaerobic sludge centrate quality is more significant than solid cake density.

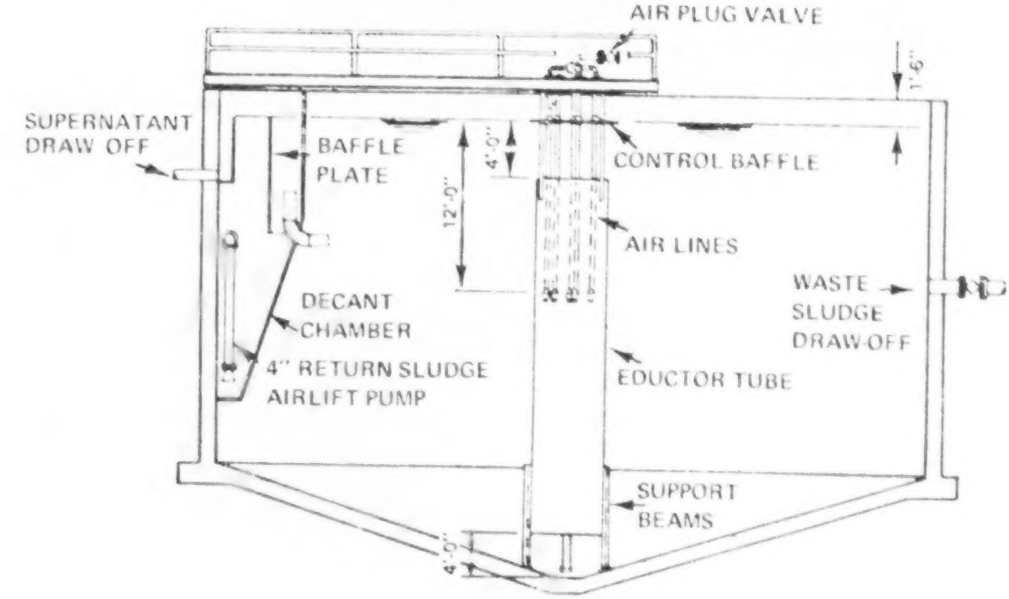
1. Determine solids volume to be dewatered
2. Determine capacity of unit based on past experience if available
3. Evaluate capture vs centrate quality

### B. Problem Identification and Correction

1. Poor capture, cake density good
   - a. Check pool depth if applicable and raise
   - b. Lower feed rate if possible
   - c. Add more polymer or evaluate other polymers for better capture
2. Cake density low, capture satisfactory
   - a. Check pool depth, if high, lower until better density is obtained (if applicable)
   - b. Vary dosage of ploymer
   - c. Consider increasing bowl speed
3. Low cake density, poor capture
   - a. Check feed rate, it may be too high
   - b. Check polymer dosage, should clear up centrate
   - c. Check pool depth, could be excessively high or low
4. Capture and cake density normal, but machine will not handle daily solids production
   - a. Consider increasing flow to centrifuge and sacrifice centrate quality
   - b. Check with manufacturer with regard to increasing bowl speed
   - c. Increase aeration time
   - d. Add chemicals
   - e. Change speed ratio
   - f. Check to see if characteristics of feed have changed


CLEAR OXIDIZED OVERFLOW TO PLANT
SETTLED SLUDGE RETURNED TO AERODIGESTER
PRIMARY SLUDGE
EXCESS ACTIVATED OR TRICKLING FILTER SLUDGE

AEROBIC DIGESTION SYSTEM
SCHEMATIC DIAGRAM


AIR PLUG VALVE
1'-6"
SUPERNATANT DRAW OFF
BAFFLE PLATE
4'-0"
12'-0"
CONTROL BAFFLE
AIR LINES
WASTE SLUDGE DRAW-OFF
DECANT CHAMBER
4" RETURN SLUDGE AIRLIFT PUMP
EDUCTOR TUBE
SUPPORT BEAMS
4'-0"

CIRCULAR AEROBIC DIGESTER

# TROUBLESHOOTING GUIDE — SOLIDS HANDLING

## IV. AEROBIC DIGESTION

A. Process Evaluation Measures
  1. Determine dissolved oxygen
  2. Determine solid concentration
  3. Determine rate of air supply

B. Problem Identification and Correction
  1. Low dissolved oxygen
    a. Possible causes
      1. Insufficient air supply
      2. Sludge overload
    b. Corrections
      1. Increase air supply, if diffused air
      2. Increase submergence, if mechanical
      3. If maximum air is being introduced, lower solids content by drawing solids off to dry beds or other methods of disposal
      4. System may have received an unusual heavy loading; check $O_2$ uptake. Observe for several days. Oxygen uptake should subside, and D.O. should increase. If not, waste solids.
      5. Check on system — diffuser plugged
      6. Blocking of mechanical aeration
  2. Excessive Detergent Foam
    a. Characterized by white to light brown light billowy foam. May look like soapsuds
    b. Probable causes
      1. Low solids in the system
      2. ABS (non-biodegradable) detergents
    c. Corrections
      1. Increase solids to approximately 1.5% or more by decanting and recycling solids back to system
      2. If solids concentration is sufficient, foam may be caused by non-biodegradable detergents (i.e. ABS) discharged by industry, usually textile. Correct by eliminating discharge, could use foam sprays in conjunction with a silicon based foam depressant for temporary relief
  3. Excessive Protoplasmic Foam
    a. Characterized by a thick gelatenous foam that may cover entire reactor
    b. Caused by excessive cell lysing usually associated with extremely high dissolved oxygen concentration, and high solids
    c. Correction: lower oxygen input and/or solids in the system
    d. Note: Protoplasmic Foam may not necessarily be a problem if contained within the reactor and desired results are obtained. Many aerobic digesters operate this way

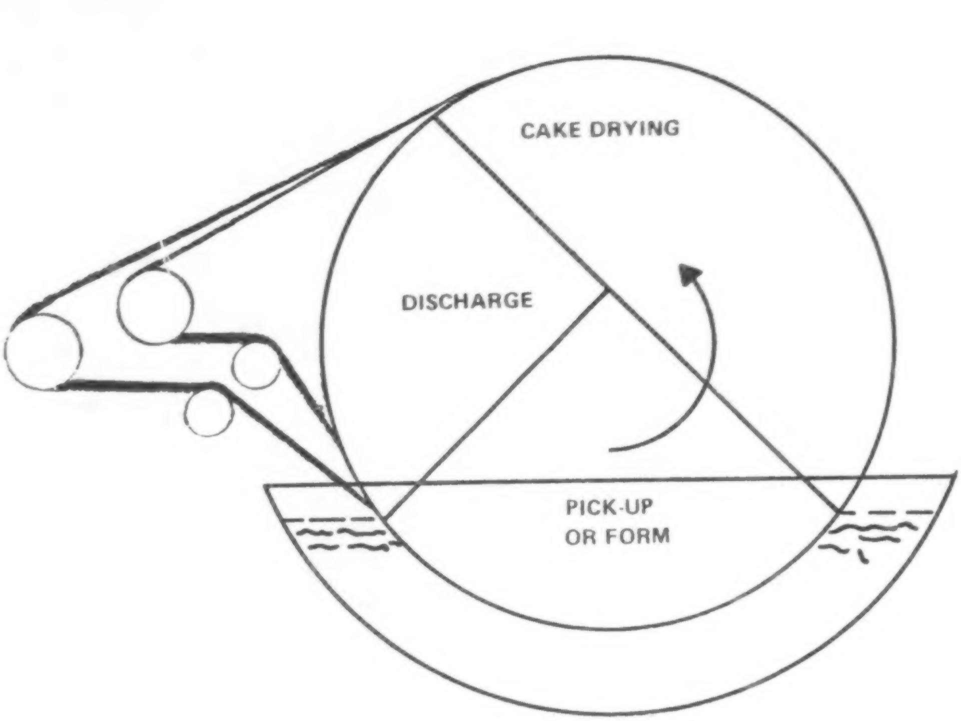
## TROUBLESHOOTING GUIDE – SOLIDS HANDLING

### V. SLUGE DRYING BEDS

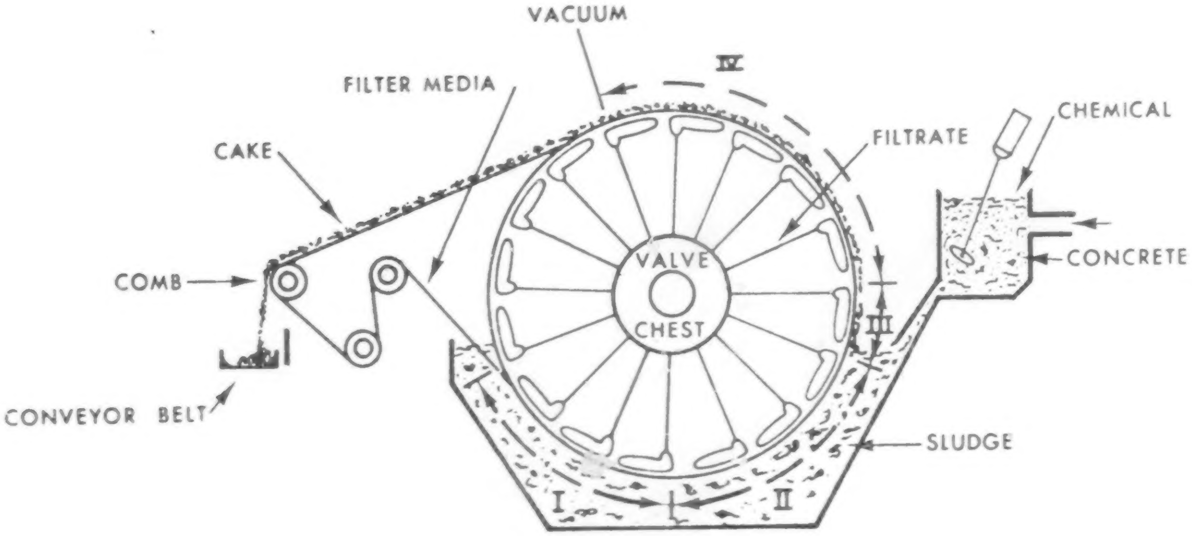
A. Process Evaluation Measures
  1. Check sludge production against area available
  2. Check records to determine actual application
  3. Check records for actual drying time
  4. Check records for sand replacement

B. Problem Identification and Correction - the most common problem is excessive dewatering time
  1. Possible Causes:
    a. Excessive application of sludge on bed
    b. Application of sludge on uncleaned bed
    c. Dirty sand on bed surface
    d. Plugged under drain system
    e. Weather conditions
    f. Septic sludge
    g. Wrong chemical dose
  2. Corrective measures
    a. Excessive Application of Sludge on Bed
      1. When bed does dry, clean and prepare properly. Then apply a smaller amount (depth) on bed and evaluate. After sand media blinds the rest of the water is removed by evaporation. A good rule of thumb is to apply a load of sludge and measure the drawn down for the first three days. Twice the draw down should be the next application.
    b. Application of Sludge on an Uncleaned Bed
      1. Little or no percolation will be observed. No corrective measures other than recognizing the problem and not doing it again.
    c. Dirty Sand on Bed Surface

      No corrective measures advised after sludge has been drawn. After sludge has dried remove sludge and dirty sand. Replace with 1-2 mm clean sand.
    d. Plugged Under Drain System
      1. With beds empty tie into underdrain piping with clean water and back-flush into beds. Note: Always start water into beds *slowly*. Repeat this process until beds drain rapidly with the clear water. Broken pipes are a real possibility.
      2. A plugged underdrain system means that somehow sludge was allowed to enter the drain system. The media above the drain should be evaluated and replaced.


CAKE DRYING
DISCHARGE
PICK-UP
OR FORM

OPERATING ZONES OF A VACUUM FILTER


VACUUM
IV
FILTER MEDIA
CAKE
FILTRATE
CHEMICAL
CONCRETE
COMB
VALVE
CHEST
III
CONVEYOR BELT
SLUDGE
I
II

ROTARY VACUUM FILTER – CAKE PROCESSING

e. Insufficient Capacity to Handle Sludge Production
  1. Evaluate use of polymer. Normally high molecular weight cationic polymer works best. Normal dosage 5-30 lbs per ton of dry solids depending on molecular weight and charge.
  2. Ferric sulfate is often useful as a coagulant aid without damaging the usefulness of the sludge as a fertilizer. In many areas it can be purchased as spent pickel liquor. Ferric chloride may be used.

## VI. VACUUM FILTRATION

A. Process Evaluation Measures
  1. Determine solids loading
  2. Determine cake concentration
  3. Determine filtrate concentration
    a. Should be less than 1.0%
  4. Determine chemical dosages
  5. Check dewaterability at dosage being used
  6. Check filter cloth condition
    a. Should be clean and not blinded

B. Problem Identification and Correction
  1. Thin poorly dewatered cake
    a. Possible causes
      1. Blind cloth
      2. Improper chemical dosage
      3. Low vacuum
      4. Improper cloth
      5. Speed too fast
      6. Submergence
    b. Corrective measures
      1. Blind cloth
        a. If dirty, steam clean and scrub with hot detergent
      2. Improper chemicals
        a. Determine proper dosage for good dewatering, then apply these dosages to the actual filter. Make field adjustments to achieve optimum results.
      3. Low vacuum in system
        a. Check all lines and relief valves for leaks, check drum operation and seals
        b. Repair where necessary or overhaul the vacuum pump

4. Improper cloth (media)
   a. Check by running leaf test kit with best dewatered sludge. Run with different types of media until best one is observed. Change on actual filter if necessary.

2. Thick Poorly Dewatered Cake
   a. Possible causes
      1. High drum speed
      2. Low vacuum
      3. Too high a feed rate
   b. Corrective measures
      1. High drum speed
         a. Slow drum speed and observe difference in cake dryness. Sometimes filters have the ability to remove solids at a higher design rate, but this usually results in high moisture content.
      2. Low vacuum pressure
         a. This is usually associated with low yield, although the filter cake is thick. Normally the drum speed slowed down to compensate for the low vacuum.
         b. If vacuum is low, check piping, relief valves (if any) and seats in the filter system. Repair where necessary.
      3. Excessive feed rate
         a. Check solids yield on filter cloth.
         b. If excessive, reduce feed rate and chemical dosage rate accordingly.

## REFERENCES – SOLIDS HANDLING

Process Design Manual, Sludge Treatment and Disposal. U.S. Environmental Protection Agency, Technology Transfer, October, 1974.

URS Research Company, Procedural Manual, Evaluating the Performance of Wastewater Treatment Plants. U.S. Environmental Protection Agency.

Zickefoose, C., and R. Hayes. Operations Manual, Anaerobic Sludge Digestion. Stevens, Thompson & Runyan. U.S. Environmental Protection Agency, February, 1976.

Gould, Robert F., ed., Anaerobic Biological Treatment Processes. A.C.S. Advances in Chemistry Series, 1971.

McCarty, Perry L., Anaerobic Waste Treatment Fundamentals. Public Works Magazine, Series of four articles, Sept. thru Dec., 1964.

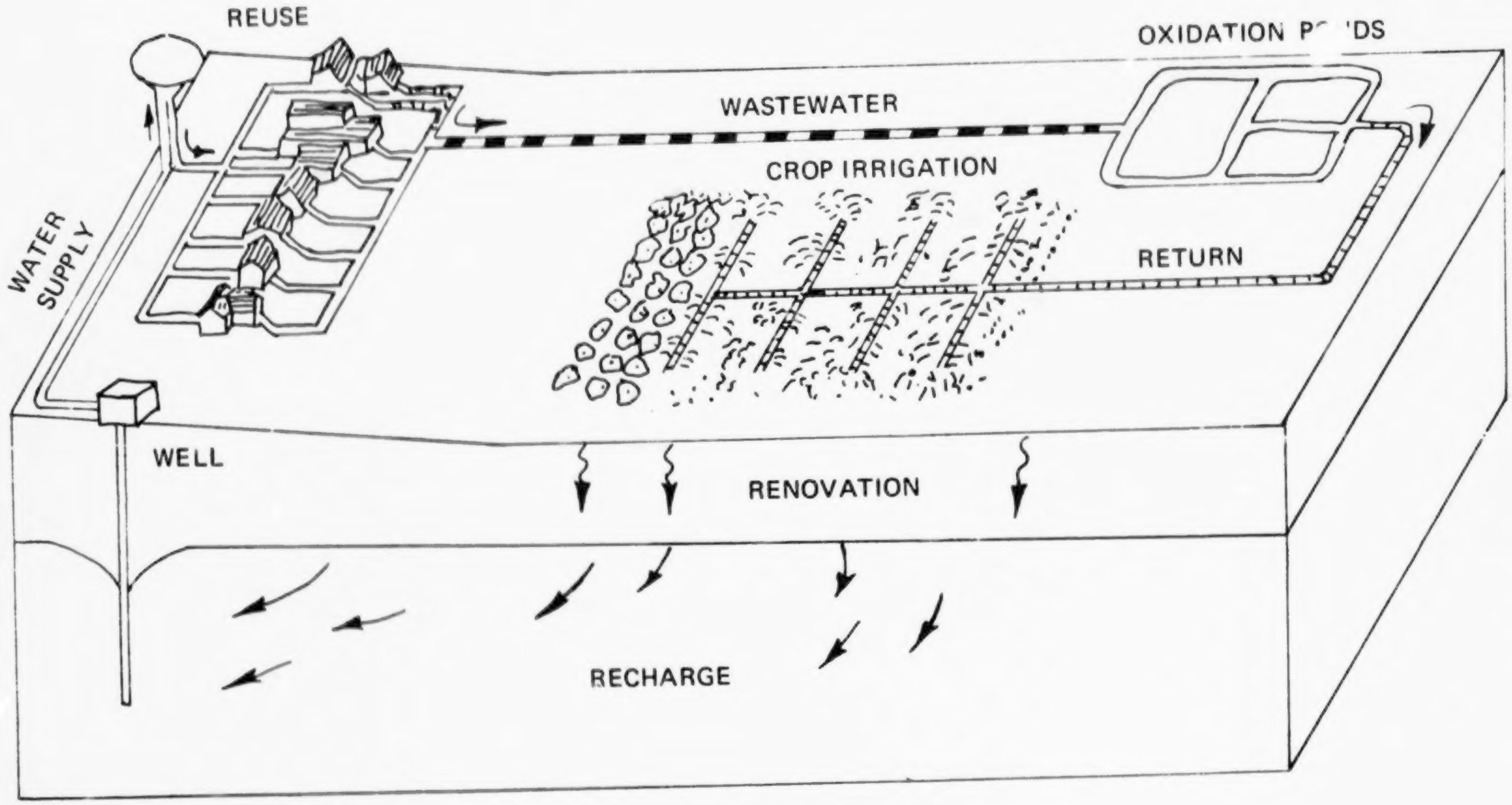
## LESSON: LAND TREATMENT

### Index of Notebook Material

| PAGES | MATERIAL | USE IN LESSON |
|---|---|---|
| LT – 1 | Application Rates of Wastewater Effluents to Land Areas | Reference by Instructor, Subdivision 1 |
| LT – 2 | 4-R Cycle of Wastewater Renovation and Conservation | Reference by Instructor, Subdivision 1. |
| LT – 3 thru<br>LT – 9 | Troubleshooting Guide – Land Treatment | Reference by Instructor, Subdivision 3 |
| LT – 10 | References | |

# APPLICATION RATES OF WASTEWATER EFFLUENTS TO LAND AREAS

1. Hydraulic Loadings
    a. Depends on infiltration capacity and conductivity of underlying geological materials
    b. 1.5 to 4.5 inches per week, 26 to 30 weeks per year, normal rate
    c. Well drained sandy soils — can use over 3 inches per week
    d. Design loading rates can't exceed vertical percolation rate, and shouldn't create excessive buildup of groundwater
2. Organic loading
    a. Depends on soils, depth of groundwater, crop, type of system
    b. Spray irrigation, normal loads of 100 to 500 pounds per acre per year
    c. Seepage basins — normal loads of 400 to 1,600 lb/acre/year
3. Nitrogen loading
    a. Varies by nitrogen concentration and hydraulic loading rate
    b. Penn State — 355 lb/acre/year yielded 97.3% removal
    c. Normal variation, spray irrigation, 50 to 250 lb/acre/year
    d. Seepage basins, normal variation, 150 to 650 lb/acre/year
4. Phosphorous Loading
    a. Penn State — 99.2% removal at 133 lb/acre/year
    b. Spray Irrigation, normal rate, 40 to 125 lb/acre/year
    c. Seepage basins, normal rate, 100 to 400 lb/acre/year


REUSE
OXIDATION PONDS
WASTEWATER
CROP IRRIGATION
WATER SUPPLY
RETURN
WELL
RENOVATION
RECHARGE

**4-R CYCLE OF WASTEWATER RENOVATION AND CONSERVATION**

## TROUBLESHOOTING GUIDE – LAND TREATMENT

I. Wastewater Pumping

A. *Problem – Pressure for a particular setting is below normal; however, the flow is above normal.*

1. Possible Causes
   - a. Broken main, lateral, riser, or gasket
   - b. Missing end plug, sprinkler, or nozzle tips
   - c. Too many laterals on at same time
2. Most serious effects
   - a. Low pressure; therefore, poor distribution
   - b. Poor distribution; therefore, poor renovation
   - c. Increased flow may cause increased horsepower and motor overload
   - d. High flow can cause pump cavitation
3. Corrections
   - a. Properly set automatic signaling device if pressure is below normal – AND when exceptionally low, automatic pump cutoff
   - b. Normal Maintenance and Operation relative to the malfunctions listed

B. *Problem – Flow for a particular setting is below normal; however, the pressure is above normal.*

1. Possible causes
   - a. Series of nozzle tips or sprinklers clogged
   - b. Lateral risers or valves clogged or partially clogged
   - c. Lateral screens may be clogged
   - d. Lateral valve may not have opened
   - e. Wastewater frozen anywhere in system
2. Most serious effects
   - a. High pressure can cause too much water in areas where sprinklers are operating
   - b. Too much water at any one location causes renovation problems
   - c. Too high pressure can cause wind drift and problems with the neighbors
   - d. Too high pressure can rupture lines, causing all types of problems – pollution, with neighbors, hydraulic, etc

3. Corrections

   a. Properly set automatically signaling device if pressure is above normal AND when exceptionally high, automatic pump cutoff
   b. Normal maintenance and operation relative to the malfunction possibilities

C. *Problem – Both pressure and flow are below normal for all settings of the distribution system.*

1. Possible causes

   a. Too much sand and grit in wastewater and impeller blades are worn
   b. Too much wear in pump
   c. Partially clogged suction or inlet screen

2. Most serious effects

   a. Low pressure and poor distribution, renovation problems
   b. Inability to pump enough water to keep up with inflow
   c. Partially clogged screen on inlet to pump could cause cavitation and require financial outlay for entirely new pump

3. Corrections

   a. Regular and detailed evaluation and troubleshooting by one having expertise in these areas
   b. Use of properly installed and operating automatic pump cutoff for high partial vacuum on suction side of pump

II. Wastewater Distribution Systems

A. *Problem – Deterioration of lateral distribution pipe, at ends or throughout pipe.*

1. Possible causes

   a. Effluent permitted to remain in aluminum pipe too long. Thus, nutrients in wastewater and dissimilar metals produced electro-chemical corrosion. This would be expected between steel valves and springs and aluminum pipe.
   b. This also happens at grain boundaries along the pipe – after a certain amount of deterioration, a pressure surge splits the pipe.
   c. Plastic pipe does not solve the problem of above ground surface lines . . . since during very cold weather plastic pipes are easily broken due to shock-loads. In direct sunlight, plastic pipe deteriorates and then ruptures due to pressure surges. The high expansion-contraction coefficient of plastic also causes problems with riser locations and with leaks in very cold weather.

2. Most serious effects

   a. Pressure loss, therefore, poor distribution
   b. Increased flow may cause increased horsepower and motor overload
   c. Wastewater runoff problems may occur

3. Corrections
    a. Bury lines of appropriate material
    b. Drain aluminum lateral lines except when actually in use
    c. Coat steel parts
    d. Cathotic or anodic protection

B. *Problem* *No flow from certain sprinkler nozzles*

1. Possible Causes
    a. Particles in wastewater too large
    b. No suction line screen on pump or suction screen may have developed a hole perhaps due to partial plugging of the screen. Thus, sprinkler nozzles may be clogged, or riser may be clogged, or valve at end of lateral may be clogged, or screen at end of lateral may be clogged
2. Most serious effects
    a. No wastewater applied where sprinklers clogged . . . poor crops
    b. Pressure too high where sprinklers open, thus too high flow, causing crop damage and/or runoff
    c. High pressures can cause line damage
3. Corrections
    a. Adequate screening at the pumphouse
    b. Frequent and careful troubleshooting of system
    c. Proper maintenance and operation

C. *Problem* *Adequate system management, particularly under adverse and severe weather conditions*

1. Possible Causes
    a. Adequate management and operation of field irrigation systems often require dedication above and beyond the regular call of duty. Such as:
        - changing valves in subfreezing weather
        - merely getting through the snow to where the valves are located
        - draining and flushing lines regularly, especially in winter
    b. Many standard M & O procedures are neglected during freezing temperatures, rain storms, or excessive snow days
    c. Working in wet grass up to one's waist isn't fun
2. Most serious effects
    a. Sprinklers clog; "lines" freeze and break
    b. Poor distribution, excess runoff
    c. All problems in all sections listed in this guide occur
    d. Wet ice is extremely slippery, especially on slopes, safety must be considered

3. Corrections
   a. Adequate salary for employees
   b. Adequate inspection with knowledgeable tips and assistance
   c. Probably most of all, however, is appropriate praise and respect for a job well done, i.e. — good management practices are needed to get the most out of the people who must maintain and operate a land treatment system

D. *Problem — Wind drifting spray onto neighbors' property*
1. Possible causes
   a. May not have been considered in design
   b. Equipment designed to stop pumps when wind comes from specific direction or reaches specific speed may have malfunctioned
   c. Wind break planted for this purpose may not have grown to adequate height as yet
   d. Sprinklers may be operating at a higher pressure than that for which they were designed
   e. Traveling sprinkler may be permitted to move too close to the field border
   f. Original wind break may have been removed
2. Most serious effects
   a. This could vary anywhere from: farmer being happy to receive this water and nutrients, to
   b. The municipality being brought into a lawsuit by a neighbor who thinks he has more infections and problems than usual
3. Corrections
   a. Provide a larger buffer area in relation to neighboring properties
   b. Adjust or move distribution system to make sure spray remains within renovation area

III. Land Renovation Areas

A. *Problem — Water is flowing off application area, with or without erosion*
1. Possible causes
   a. Related to renovation system:
      1. Infiltration rate too low — poor soils
      2. Soil surface sealed by solids, preventing infiltration
      3. Waste material forms mass on soil surface which destroys soil aggregation and prevents infiltration
   b. Related to distribution system
      1. Irrigation rate too high
      2. Broken line or deteriorated pipe
      3. Broken coupler latch, or displaced end plug
      4. Nozzles broken at other locations, thereby increasing pressure and flow at one application point

c. Too much rain in recent past

2. Most serious effects

a. Wastewater runs off area without being renovated
b. Pollution of neighboring property, water supplies, etc.

3. Corrections

a. Related to renovation system
1. Strip crop area or put into permanent sod
2. Terrace or use diversions
3. Underdrain if soil is appropriate, etc.
4. Keep soil well covered with grass or mulch
5. Irrigate only sandy single grained soils
6. Keep BOD low enough to be compatible with temp., soil, crop, etc.

b. Related to distribution system
1. Condition can be corrected primarily by normal maintenance and operation
2. Place sprinklers farther apart
3. Decrease nozzle diameter of each sprinkler and increase the length of laterals and number of sprinklers
4. Reduce irrigation rate

c. Don't irrigate if soil is saturated from natural rainfall

B. *Problem — Erosion of Soil*

1. Possible Causes

a. Most of the causes of Problem A, *Overflow off of land area*, can also cause soil erosion
b. Land remaining uncovered over long periods
c. Planting of the wrong crop for the soil

2. Most serious effects

a. Loss of fertile soil
b. Poor quality runoff, downstream water quality problems, including nutrients and pesticides
c. Deposition of soil in ditches, canals and downstream waterways

3. Corrections

a. Most of the corrections for Problem A may be applicable
b. If problem is with crop or soil, consult county agent or other agricultural specialist

C. *Problem — Crop that was being irrigated is dead*

1. Possible causes

a. Too much water applied
b. Too much of certain nutrients applied, i.e. crops need certain nutrients and only certain amounts of these, too much of most any nutrient will kill the crop

   c. Too much of any type detrimental chemical — weed killers, etc. through treatment plant — from area runoff or disposed of through drains

2. Most serious effects
   a. "Dead crop makes a darn poor living filter," i.e., the system just isn't working
   b. Dead crop adds to BOD load
   c. Infiltration is decreased, runoff can occur or increase
   d. Nutrients are not removed
   e. Unsightly area — neighbors concerned
   f. Excess odors — neighbors concerned

3. Corrections
   a. Close monitoring of all inflows to the treatment plant, including industrial wastes
   b. Monitor plant effluent for toxic materials
   c. Reduction of high flow rates
   d. Modification of nutrient balance applied to the crop
   e. Consult with county agent or other agricultural specialist

D. *Problem — Areas of Water Pooling or Sink Holes*

1. Possible Causes
   a. Broken mainline
   b. Inoperative valve, mechanical or electrical malfunction
   c. Electrochemical corrosion
   d. Insufficient pressure to seal portable pipe
   e. Improper choice of site in design or adding water beyond design limits
   f. Any malfunction or improper operation that causes an excess of wastewater to be discharged

2. Most serious effects
   a. Dangerous to farm operating equipment
   b. Unsafe to man and animals, especially before final cover on surface has fallen in
   c. Pollution of groundwater in general or to private, town, or industrial water source which usually ends in law suit
   d. Continued loss of renovation effect, possible loss of use of entire system, which is tremendous financial loss

3. Corrections
   a. Inspection and evaluation by professional persons with experience and expertise in this area
   b. Install adequate surface drainage early in construction or very early in operation
   c. Sound maintenance and operation, with lots of good common sense

E. *Problem — Small corn ears, cobs not filled out with kernels, yellow corn leaves, crop not responding as it ought.*

1. Possible causes
   a. Too much water applied — same as before
   b. Too little nutrients applied
      - crop does not have enough nutrients to go to maturity
      - crop too thick for nutrients applied
      - too much grass in corn, competition
   c. Nutrient applied too early
      - then irrigation water leached nutrients through soil into groundwater or out into stream (this nutrient loading may be worse than original effluent).
   d. Nutrients may have been of wrong type for time they were applied
2. Most serious effects
   a. Poor economical balance
   b. Increased pollution per nutrient leaching
   c. Detrimental outlook effect on farmer, operator, etc., thus have "don't care" attitude in other work
3. Corrections
   a. Advice from County Agent, S.C.S., and/or professional agricultural consultants with this type experience
   b. Good maintenance and operation of entire distribution and renovation system

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## LESSON: CHLORINATION

### Index of Notebook Materials

| PAGES | MATERIAL | USE IN LESSON |
|---|---|---|
| CH – 1 | Uses and Dosage of Chlorine | Reference by instructor, Subdivision 1, Section I |
| CH – 2 | Operation of Chlorine Facilities | Reference by instructor, Subdivision 1, Section VI |
| CH – 3 | Chlorine System Points of Concern and Typical Malfunctions and Deficiencies | Reference by instructor, Subdivision 2, Section III |
| CH – 4 | Chlorination Troubleshooting Guide | Subdivision 2, Section IV To be completed as class exercise by student groups |
| CH – 5 | References | |

## USES AND DOSAGE OF CHLORINE IN A WASTEWATER TREATMENT PLANT

| Type of Chlorine Use | | Specific Application | Dosage in PPM | Recommended Residual in PPM |
|---|---|---|---|---|
| 1. Disinfection | A. | Remove pathogenic organisms from treatment plant | Depends on local conditions and permit requirements | Depends on local conditions and permit requirements |
| 2. Prevention of Sewage Decomposition | A. | Odor Control at: | | |
| | | 1. Sewers and influent point | 1. 1.5 – 10 | 0 |
| | | 2. Overload secondary treatment facilities | 2. 5 – 10 | 0 |
| | B. | Protection of plant structures by controlling corrosion | | |
| | C. | Sludge thickening | | |
| 3. Upgrading Plant Operations | A. | Sedimentation | | |
| | B. | Trickling filters | | |
| | | 1. Odor control | 1. 2 – 6 | 0 |
| | | 2. Filter ponding & clogging | 2. 5 – 40 | 1 – 2 |
| | | 3. Trickling filter flies | 3. 3 – 10 | 0.1 |
| | C. | Activated Sludge | | |
| | | 1. Sludge bulking control | 1. 2 – 8 | 0 |
| | | 2. Sludge thickening | 2. Variable | 1.0 |
| | D. | Imhoff tank foaming | 3 – 15 | 0 |
| | E. | Grease Separation | | |
| 4. Reduction or Delay of BOD | A. | Apply during overload or emergency conditions to prevent oxygen depletion in receiving waters. | 6 – 12 | 0.2 – 0.5 |

# OPERATION OF CHLORINE FACILITIES

## OPERATION INFORMATION

Do not heat cylinders
Do not put water on leaks
Do not run lines through differing temperature zone
Do not immerse cylinder in water
Do not put mask with chlorine
Do not use rubber hose for chlorine lines

Do use proper chlorine wrench
Do read cylinder tags
Do ventilate chlorine room
Do roll leaking cylinder to emit gas not liquid
Do learn emergency procedures
Do always use new washers
Do open cylinder completely

## CONNECTIONS

Use yoke and adapter
Use copper tubing type K
Avoid using aluminum or stainless steel
Carbon steel schedule 80 seamless may be used

## EMERGENCY PROCEDURES

Evacuate the area
Apply gas mask
Locate leak with ammonia mist or rag
Shut off chlorine
Shut off chlorinator if connected
Position cylinder to emit gas not liquid
Tighten threaded fittings if leaking
Apply proper safety kit device
Disconnect cylinder and remove
Call supplier and advise

## CHLORINATION SYSTEM POINTS OF CONCERN

A. Chlorine room

B. Chlorine cylinders

C. Chlorine scales

D. Chlorine supply lines

E. Chlorinator system

  1. Pressure reducing valve and shutoff valve
  2. Feed rate indicator
  3. Pressure gauge
  4. Variable orifice for feed rate control
  5. Vacuum regulating valve
  6. Injector or vacuum producing device
  7. Control systems

F. Chlorine contact tanks

G. Effluent sampling point

H. Downstream receiving water

## TYPICAL CHLORINE APPLICATION MALFUNCTIONS AND DEFICIENCIES

1. Insufficient chlorine gas pressure at the chlorinator
2. No chlorine gas pressure at the chlorinator
3. Icing of rotameter tube and supply line
4. Absence of chlorine flow
5. Leaking of chlorine gas
6. Closing of external chlorine pressure reducing valve
7. Insufficient chlorinator feed rate
8. Excessive chlorine odor at point of application
9. Inadequate chlorine residual at sampling point
10. Wide variation in chlorine residual
11. Improper control at residual analyzer
12. Coliform count fails to meet required standards
13. Chlorine residual exceeds toxicity requirements

## CHLORINATION TROUBLESHOOTING GUIDE

**To be completed by student groups and class discussion**

| **PROBLEM** | **POSSIBLE POINTS OF OBSERVATION** | **POSSIBLE POINTS OF MALFUNCTION** |
|---|---|---|
| 1. Low gas pressure | a. Pressure gauge<br>b. Supply line | a. Pressure reducing valve<br>b. Supply line |
| 2. Zero gas pressure | | |
| 3. Icing | | |
| 4. Absence of chlorine flow | | |
| 5. Leaking of chlorine flow | | |
| 6. Closing of pressure reducing valve | | |
| 7. Insufficient feed rate | | |
| 8. Excessive chlorine odor | | |
| 9. Low chlorine residual | | |
| 10. Variation in chlorine residual | | |
| 11. Improper control at residual analyzer | | |
| 12. High coliform count | | |
| 13. Excessive chlorine residual | | |

*References:* Notebook Page CH-3
EPA Manual "Evaluating the Performance of Wastewater Treatment Plants," pp 89-108

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☆U.S. GOVERNMENT PRINTING OFFICE: 1977-757-056/5537